SOIL SURVEY OF KOSCIUSKO COUNTY, INDIANA

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DESCRIPTION OF THE AREA

Kosciusko County is situated in the northern part of Indiana. The northeastern corner is 25 miles south of the northern boundary of the State, and about 120 miles southeast of Chicago. The outline is approximately a quadrangle. It has an area of 541 square miles, or 346,240 acres.

Broadly considered, the surface features range from level plains to much more extensive areas where the topography varies from undulating to rolling. The general elevation above sea level varies from 800 to 900 feet. In places, hilly to somewhat broken relief prevails; but there is very little land so rough as to be actually untillable. There are numerous basins and depressions, many containing lakes and muck areas ranging in size from 10 to several hundred acres. Two of these areas include several square miles each. Some are mere sags in the surface, hardly noticeable except for the black color of the soil.

FIG. 38.—Sketch map showing location of the Kosciusko County area, Indiana

The northwestern quarter of the county is a slightly uneven plain, with a few prominent ridges. Much of this section is very gently undulating, and the average elevation is only a few feet above that of the wide flats in the vicinity of Leesburg. Farther south and southeast the relief becomes somewhat stronger, remnants of forests are more numerous, and the country in general is more representative of north-central Indiana.

The northeastern quarter of the county is more diversified. Much of it consists of uplands of pronounced elevation, when compared with the lands to the south. The configuration of the ridges ranges from gently rolling to somewhat broken. There are many beautiful lakes where the marginal variations of woodland, marsh, and cultivated fields add to the beauty of the landscape. These lakes lie in outwash plains, which are wide slightly undulating areas usually bounded on the side toward the water by sharp declines of from 10 to 40 feet. The largest of these terracelike plains surrounds the Tippecanoe group of lakes and reaches southward below Chapman Lake and also extends in a general westward direction beyond the limits of the county.

A few square miles in the extreme northeast corner of the county are essentially a high plain, whose southern escarpment overlooks Lake Wawasee.

The southern half of the county consists chiefly of uplands of moderate elevation and mild relief. There are a few lakes and numerous shallow depressions. The rougher lands are of limited extent and are usually found near the lakes and marshes. In the southeastern township, the Eel River drainage gives rise to some narrow troughlike valleys along the small creeks. In this township the river bottoms are narrow, and wide elevated terraces occur on each side.

The main drainage system of Kosciusko County is the Tippecanoe River and its tributaries. The extreme southern part is drained by the Eel River and its branches; the northwestern section, by tributaries of the Kankakee River; and the northeastern part, by tributaries of the St. Joseph River.

The former poorly developed drainage of the northwestern townships has been greatly improved by the straightening and enlarging of the creeks, and by the construction of canals and ditches to give isolated depressions adequate outlets. On the sandy terrace plains little or no natural drainage lines have developed, since most of the rainfall is absorbed by the open porous soil and passes into the underground drainage. Some of this water reappears in springs, which are numerous along the foot of the gravelly slopes bordering the lakes. There are comparatively few streams in the uplands, and these have very short tributaries. Much of the local surface drainage terminates in depressions.

Farm wells on the uplands range from 75 to 150 feet in depth. Shallow wells on the plains furnish much water, but in many instances driven wells, from 50 to 100 feet deep, give a better quality of water and a more dependable supply.

The water table on all flat lands has become permanently lower. This is also true in some measure on the sandy plains and uplands. Many small lakes have disappeared since the county was settled, and the levels of the larger ones are now maintained by dams. Practically all the lakes were doomed to extinction, from natural causes, particularly during the early occupancy of the country. The present strong sentiment against further reduction of the larger lakes will doubtless insure their preservation.

Native born Americans form by far the larger proportion of the population of the county. The 1920 census reports 27,120 inhabitants, of which 21,642 are classed as rural, being residents of farming sections and of the small incorporated towns. The rural population has declined several hundred since 1910, every township except those in which Warsaw and Pierceton are located suffering a loss. Warsaw, the county seat, gained about 1,000, and had a population of 5,478 in 1920. Mentone, Milford, Leesburg, and Syracuse are well-built towns each of several hundred population. Winona Lake and the lakes in the northern part of the county attract hundreds of visitors each summer.

The Baltimore & Ohio Railroad crosses the extreme northern part of the county; the Pennsylvania Railroad, the central part; and the Nickel Plate (the New York, Chicago, & St. Louis Railroad), the southern—all affording direct transportation to Chicago. The Big Four Route (the Cleveland, Cincinnati, Chicago & St. Louis Railway) crosses the county from north to south. The

Winona Interurban connects Warsaw, Mentone, Leesburg, and Milford with Indianapolis, Elkhart, and South Bend.

Nearly all the country roads are surfaced with gravel, and the county has several miles of concrete highway. Practically every farmhouse has telephone service. All but a few townships have consolidated schools.

CLIMATE

The following table, compiled from the records of the United States Weather Bureau station at Winona Lake, gives the normal monthly, seasonal, and annual temperature and precipitation at that station:

Normal monthly, seasonal, and annual temperature and precipitation at Winona Lake

(Elevation 865 feet)

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1909)
	° *F.*	° *F.*	° *F.*	*Inches*	*Inches*	*Inches*
December	28.7	61	−12	2.13	2.12	2.62
January	24.3	62	−20	2.67	2.09	2.77
February	25.0	63	−16	2.05	2.11	4.85
Winter	26.0	63	−20	6.85	6.32	10.24
March	37.1	85	−3	2.67	.17	2.58
April	49.6	87	16	3.32	3.90	4.23
May	60.3	98	28	4.54	3.86	3.47
Spring	49.0	98	−3	10.53	7.93	10.28
June	68.5	101	35	3.68	.77	7.80
July	74.0	103	44	3.16	1.72	3.53
August	72.0	105	37	2.94	2.48	1.67
Summer	71.5	105	35	9.78	4.97	13.00
September	64.3	100	29	2.98	5.61	2.80
October	53.5	87	21	2.83	1.85	2.29
November	40.6	76	9	2.55	2.22	4.55
Fall	52.8	100	9	8.36	9.68	9.64
Year	49.6	105	−20	35.52	28.90	43.16

The difference of 14 inches in precipitation between the driest and wettest years is exceptional, but minor variations which affect crops to a considerable degree are of common occurence and must be considered in cultural operations.

The normal rainfall of July and August is not too much for corn on any soil type. Usually it is insufficient or not well enough distributed for the more sandy soils. On the latter the late-summer rainfall is a very large factor in corn production, clover growing, and in the production of fruits.

The snowfall is irregular, and under these conditions, its influence upon fall-sown crops and young clover is a subject concerning

which farmers hold different opinions. The Weather Bureau reports show no snowfall records for Winona Lake, but the records for Plymouth, in Marshall County, show an average annual snowfall of 31.9 inches.

The average date of the last killing frost in the spring is May 6; of the first in the fall, October 10. The earliest recorded killing frost in the fall occurred on September 11; and the latest in the spring, on June 16. The crops on low isolated depressions are most subject to frost injury. The lakes are said to afford much protection from frost along their immediate borders. The uplands are more free from frosts than the muck beds and depressions that are entirely surrounded by higher ground.

In general, the very great variety of native plants, shrubs, and trees, and the rather wide range in kinds of cultivated crops indicate climatic conditions favorable to a diversified agriculture.

AGRICULTURE

The early agricultural development of the county followed the course common to the settlement of forested sections of northern Indiana. The best drained lands were occupied first, and the clearings were gradually extended into small areas of poorly drained land where little or no cooperative effort was necessary to obtain drainage outlets. The construction of most of the large ditches and the deepening of small creek channels have mostly been done within the last 25 years. It is estimated by some residents that 50 years ago between a third and a half of the county was still forested. A very small proportion of the land has been cultivated for more than 50 or 60 years, and only occasional fields longer than 75 years.

The constant addition of new land, much of it being dark-colored soil, has been a more important factor in maintaining or increasing crop yields than the introduction of fertilizers or improvements in methods. In general, the crop yields on the light-colored soils decline rather rapidly during the first few years after clearing, and then they assume a comparatively uniform but lower level for a long period. The dark-colored soils in cultivation have as yet suffered little decline in productiveness. Approximately 95,000 acres were under tile drainage in 1921, according to the assessor's returns.

Corn, wheat, oats, and clover have long been the staple crops. In recent years there has been a notable increase in variety and quantity of products grown for canneries, for the tourist trade at the lakes, and for the markets in near-by cities. The value of tomatoes, cabbage, cucumbers, and melons, together with small quantities of other garden crops, amounts to many thousands of dollars each season. Sugar beets, hemp, and mint are of local importance in the northwestern part of the county.

The following table, compiled from census returns, shows the acreage and production of the principal crops for the years 1879, 1889, 1899, 1909, and 1919:

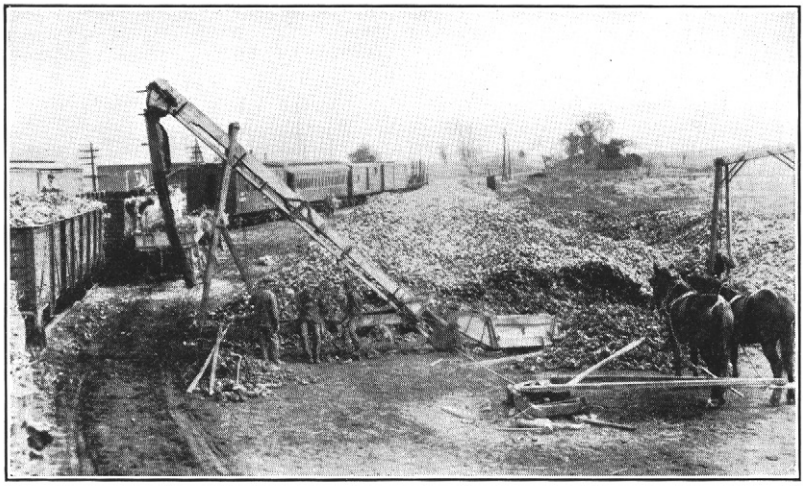

FIG. 1.—LOADING SUGAR BEETS AT MILFORD JUNCTION

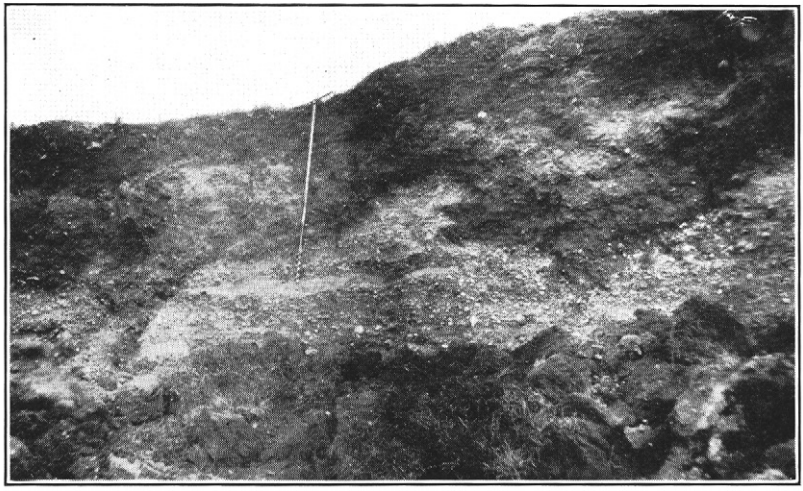

FIG. 2.—SECTION IN GRAVEL PIT IN BELLEFONTAINE SANDY LOAM. DARK REDDISH-BROWN, WELL OXIDIZED LAYER OVER GRAY, CALCAREOUS GRAVEL

Acreage and production of leading crops in 1879, 1889, 1899, 1909, and 1919

Year	Corn		Oats		Wheat		Rye		Hay	
	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Tons*
1879	37,702	1,256,807	10,047	324,475	43,725	889,125	187	2,822	18,894	26,845
1889	44,943	1,420,988	20,268	747,746	44,664	882,843	510	7,034	32,607	39,757
1899	53,057	2,206,780	13,890	491,110	43,734	348,010	759	10,200	34,044	42,595
1909	60,276	2,311,827	31,528	1,028,582	36,911	718,702	3,630	56,700	31,354	41,122
1919	57,173	2,069,567	22,626	654,002	48,888	765,339	10,984	156,879	35,017	39,638

The increase in the acreage of corn and oats is due largely to extension of the cultivated areas. The wheat acreage in general has declined, the increase in 1919 being due to the demands created by the World War. It is very apparent that marked seasonal variations in yields and insect pests have discouraged wheat growers. In 1920 the wheat crop was almost entirely destroyed by the Hessian fly. In 1921 about 22,000 acres of wheat were harvested, and 27,000 acres were sown in the fall, according to assessor's returns.

A larger proportion of the corn grown on the dark-colored soils is sold direct from the farms than of that produced on the light-colored soils. In fact, from most of the farms on the latter types very little corn is sold, it being fed on the farms. In most cases where grain rent is paid, the landlord's share is sold. It is highly probable that less than 10 per cent of the entire corn crop leaves the county. In general, all the wheat and more than half of the oats are sold off the farms.

Dairying has not been extensively developed. Near each town there are farmers who specialize more or less in this business, and on the majority of farms milk or cream constitutes an important source of income. The assessor's returns for 1921 show a total of 12,243 dairy cattle of all ages in the county and 7,423 beef cattle. The total number of swine in 1921 was about 30,000. As in most counties where corn is the principal crop, the sale of fat hogs is an important item of income on practically every farm. About 10,000 sheep are reported by the assessor's returns for 1921.

The importance of the poultry business is indicated by the number of small farms on which chickens are raised in large numbers. The number of laying hens reported in January, 1922, was 235,760.

A canning plant in Warsaw creates a market for the tomatoes, cabbage, and cucumbers grown in that vicinity. At Pierceton a large catsup-manufacturing plant takes the produce from a considerable acreage of tomatoes. The average yield of tomatoes on well-tilled fields is about 10 tons per acre. A considerable acreage of watermelons, cantaloupes, and some garden truck is grown in the lake region. The hotels and summer residents create a constantly increasing demand for such products.

Several thousand tons of sugar beets are grown annually on the dark-colored soils in the northwestern part of the county. The beets are shipped to a sugar factory at Decatur. (Pl. XXXI, fig. 1.) In 1920 the yields varied from 8 to 14 tons per acre.

Onions are regularly grown by a few farmers. Fields devoted to onions seldom exceed 10 acres in size. Many farmers raise from 1 to 5 acres, but they are not the regular producers.

The possibilities in fruit farming are indicated by the quantity and variety of fruits produced in farm orchards. As a rule these are not very well cared for, but they include old trees of approved varieties that yield very regularly. In one orchard that has received good care, 38 varieties of apples are grown, besides many kinds of plums, and other less common kinds of tree fruits, such as quinces, apricots, and sweet cherries. Several small commercial apple orchards are in bearing, the apples being chiefly of standard varieties.

The adaptability of the dark-colored soils for corn is reflected in the high prices these types command. Light-colored, well-drained soils are preferred for winter wheat. Oats and clover are grown on practically all types. Seasonal conditions seem to be more important factors in crop production than soil variations. Many farmers express a preference for the light-colored soils, for the reason that these soils, excepting the very sandy types, endure seasonal extremes well if properly handled, and that they are somewhat safer with respect to frost.

Truck growers state that tomatoes grown on the light-colored and rather gravelly soils are less watery and have firmer flesh than the same varieties grown on Muck or other black soils.

The predominance of farms of less than 160 acres does not favor the general use of tractors, gang plows, two-row cultivators, and the larger types of haying and harvesting machinery.

According to assessor's returns for 1921, there were on farms 2,082 automobiles, 50 trailers, 67 trucks, 2,033 cream separators, and 6 milking machines.

Farm houses include many rather small frame buildings, larger houses of the type built 60 years ago, and a considerable number of more modern houses. Big red "Pennsylvania bank" barns are very common. On most farms other buildings include double corncribs, poultry houses, and garages, and less commonly, modern hog houses and silos. A few yard trees and an orchard afford about the only shelter for buildings. The wood lots are commonly apart from the home surroundings.

The farming methods in common use are similar to those prevailing throughout the Corn Belt. Fall plowing is not commonly practiced, spring plowing often being preferred on account of the utilization of fall pasturage. Disk harrows are generally used. Cultipackers are in favor for fitting light soils for all crops, and the heavier soils in dry seasons for fall-sown grain. Corn is given from three to five cultivations. For corn many farmers prefer drilling instead of "checking," especially on light soils. In harvesting, a very large proportion of the corn crop is shocked, and later husked by hand. On a few farms a considerable part of the corn is shredded. The 534 silos in the county (1922) care for about 3,200 acres of corn. Occasionally wheat or rye is sown in the fall on corn ground. The protection afforded by stalks may influence winter conditions. Threshing grain from the shock is a common practice. Very little straw is sold.

The census of 1920 reported 3,355 farms in the county. There are 1,242 farms containing more than 50 but less than 90 acres; 953, ranging in size from 100 to 174 acres; and only 68 farms of more than 500 acres each. The farms average the largest in the prairie sections and on the smoother lands of the southern part of the county. Small holdings are mostly near the towns and on the more rolling types.

The great majority of farms are operated by the families who occupy them. The moderate size of holdings and the considerable diversity in crops obviate the necessity of much additional help in any particular season. Exchange of labor between neighbors is a very common practice. No colored or foreign labor is available.

The condition as regards tenure of farms has been fairly stable during the decade, 1910 to 1920—the number of farms operated by tenants being 30 per cent in 1910 and 32 per cent in 1920.

The prevailing rate of rent is one-half of all grain, delivered at the nearest market, and cash compensation for hay and grass land. One-year leases are common. Partnerships between owner and tenant, so that better crop rotations may be followed and more live-stock handled, are coming into favor, but unfortunately leases on this basis are not common.

During the World War the prices of land did not advance so much in this county as on the dark-colored prairie lands of Illinois and Iowa. A few transfers at about 25 per cent increase were made. Comparatively few farms have changed hands in recent years.

Wheat or oats, followed by two years of clover and timothy, and then corn is the common sequence of crops. If the clover fails, oats may be sown again, but as a rule corn is grown just as frequently as possible. On the black soils less clover is sown than on the light-colored ones. The common practice of cutting all the clover for hay or for seed leaves but little crop residue for plowing under, In 1921 the acreage of clover alone was 10,927 acres; of clover and timothy mixed, 16,767 acres; and of timothy alone, 9,458 acres, according to the assessor's returns.

Truck crops are not generally grown successively on the same ground. Soy beans and cowpeas are coming into favor as secondary crops in corn, about 300 acres being planted in 1921.

The expenditure for commercial fertilizers in 1900 was $5,000. This was doubled in 1910, and the 1920 returns show an expenditure of about $100,000, owing chiefly to high crop prices and the increased acreage of wheat. The quantity of fertilizer under normal conditions is steadily increasing, most of it being used on wheat and truck crops. In 1920, 16 per cent acid phosphate was extensively used on farm crops. The complete fertilizers used seldom contain more than 2 per cent of potash or of nitrogen. However, such mixtures are not used on many grain farms. About 1,285 tons of commercial fertilizer and about 150 tons of agricultural lime were applied to soils in 1921 (from assessor's returns). Peat or muck has been used by some farmers as a soil amendment for the light-colored types, but the profitableness of using these local materials under present conditions remains to be demonstrated.

SOILS

On the soil map of Kosciusko County, 20 soil types and 4 phases of types are shown. Muck, Peat, and Swamp lands are also indicated, the Muck and Peat being grouped together.

The soil type is the unit in soil mapping. A type includes all areas in which the soil has the same distinguishing characteristics. A soil series is a group of soils having like characteristics but differing in texture, that is, in their content of sand, silt, and clay.[1]

The soils of this region have developed from glacial deposits which are so deep that the underlying hard rock formations are nowhere exposed. The glacial drift, which is the parent material of most of the upland types, is a pale yellowish-brown to light-buff mixture of silt and clay, carrying a variable proportion of sand, gravel and small stones. It contains a high percentage of lime carbonate, both in the forms of fine material and as gravel and stone. Some morainic ridges occur which are composed chiefly of sands and gravels.

On the outwash plains, which are level tracts in the lake regions, sand and gravel of finer texture than those of the ridges are the predominant materials to a depth of many feet. There are occasional exposures of a light-blue clay under this gravel, which influences the ground-water level but does not contribute directly to the soil material.

In all these deposits limestone fragments are numerous, and there is enough shale and sandstone to suggest that a very large proportion of the till has come from sedimentary rocks. The more resistant rock fragments include fine-grained granites, gneisses, diorites, various metamorphic rocks, quartz, and chert. The decomposition of the softer rock fragments has generally progressed to depths of from 3 to 6 feet.

The removal of the more soluble minerals by solution and leaching has occurred in varying degrees, depending on structure of the material, local elevation, and internal drainage. As indicated by the oxidation of the iron and the removal of the lime, this leaching has not been very generally effective below 30 or 40 inches in the heavier material of the till, and at somewhat greater depths in the sandy and gravelly material of the outwash plains.

The present stage in soil development on the outwash plains may be observed in almost every gravel pit. Below the loose, well-leached surface soil there is usually a subsurface layer, 10 or 15 inches thick, which is lighter colored and contains more fine earth than the surface layer, and is nearly as deficient in the softer rock fragments as the surface zone. Below this there is a third zone of reddish-brown, sticky, or (if dry) more or less firmly cemented gravelly sandy clay, 2 or 3 feet thick, which rests upon loose, grayish, highly calcareous gravel. The upper light-textured layers are composed very largely of sand grains, pebbles, and other materials which are more or less resistant to weathering. The reddish-

[1] The terms sand, silt, and clay refer to size of soil particles. Very fine sand particles are barely visible to the naked eye; silt, the next finer grade, is microscopic; and clay particles are exceedingly minute. A predominance of silt gives a degree of porosity highly favorable to good moisture conditions. Clay imparts plasticity, and causes a soil to clod on drying or to become sticky on wetting.

brown layer, containing much clay and colloidal material, is largely the product of decomposed softer rocks. To this layer has been added some clay and silt by translocation from the layers above. The division between the reddish-brown material and the gray gravel is sharply defined, although the former often extends a few yards down into the latter in tongues and columnar masses 2 or 3 feet in diameter.

On the uplands, where the till consists largely of clay material, the depth and degree to which oxidation has been effective is seldom as great as where the material is gravelly. Where the material below the surface layer or topsoil is a silty clay or clay loam, mottled coloration, in which gray is much in evidence, usually occurs at a depth of less than 30 inches; and just below this layer the parent material may be found. The grayish or mottled layer is usually more or less compact, but is seldom so impervious as to offer serious resistance to water movement.

As a rule all the darker-colored types have developed under poor natural drainage; and the light-colored soils, with some minor exceptions, under conditions of good drainage. Well-drained lands in this latitude which have been in forest for centuries, have accumulated very little organic matter. The organic matter is confined to the immediate surface layer and is of such a nature that it soon disappears when the land is tilled. In poorly drained depressions more organic matter has become incorporated with the mineral soil, and has been preserved, producing black or very dark-brown soils. Some of the flat black lands of the northwestern part of the county were wet prairies until they were artificially drained.

The heavier types of the Miami soils are the dominant soils on the upland of the central and southern parts of the county. They are characterized by grayish-brown surface soils overlying a lighter-colored subsurface layer of similar texture. The subsoil is somewhat heavier, slightly compacted, and in places not uniformly oxidized. Lime has generally been leached to a greater depth than 3 feet.

The Crosby soils, generally, have developed under poorer drainage conditions than the Miami, as indicated by their somewhat ashy-gray surface layers and mottled subsoils. The substratum of friable, highly calcareous material occurs in many places at a depth of less than 30 inches from the surface. The individual areas are small and are not, as a rule, typically developed.

The types of the Bellefontaine series are characterized by predominance of brown color rather than the gray or mixed colors of the preceding series. Oxidation of the iron and leaching of the lime carbonates have occurred to a depth of 40 or 50 inches.

The soils of the Coloma series are light brown to grayish brown in color, and the subsoil ranges from yellow to reddish. They are formed from very sandy, glacial material, largely quartz. The topography varies from rolling to rough and hilly.

The Clyde soils are characterized by nearly black surface soils, rich in organic matter, underlain by gray subsoils. These soils have developed under wet conditions. The prevailing level of the ground water, under natural conditions, was at or above the line of contact of the dark and light layers. On many areas the light-colored

layer is calcareous, and there has been little segregation of iron as concretions or aggregations.

In the Brookston soils the average level of the natural water table is lower than in the Clyde. The Brookston soils are very dark grayish brown rather than black, probably because of a lower content, or a more advanced stage of decomposition, of organic matter, as compared with the Clyde.

The Maumee soils resemble the Clyde soils in surface appearance. The substratum includes much coarser textured material resting upon a deeper stratum of calcareous gravel. The Maumee types are essentially wet prairie soils. The natural conditions favored a heavy growth of grasses and the preservation of their remains.

The Warsaw soils represent better-drained prairies. There is probably less organic matter in the surface layers of these soils than in typical soils of the Maumee group.

The Fox and the Plainfield series embrace soils of the well-drained parts of the outwash plains which were mostly in forest. Their characteristic brown colors are due to rather deep and effective oxidation of the parent material. The material seems to have been originally more sandy with a much higher proportion of quartz where the Plainfield soils occur than where the Fox soils predominate. The heavy subsoils of the Fox types may be due to the decomposition of softer rock originally contained in the varied materials which formed these outwash plains.

Small areas of recent sediments are classed as Genesee soils. They resemble the brown soils found in the larger valleys farther south in the State.

The recession of the lakes and the drainage of small ponds, during recent years, have resulted in an increase in Muck and Peat lands. Ponds and swamp spots, after being drained, commonly become areas of Clyde and Maumee soils.

The soil types of Kosciusko County are described in detail in subsequent pages of this report. Their distribution is shown on the accompanying soil map. The table below gives the extent in acres of each soil mapped, and the percentage of the total area of the county credited to each type:

Areas of different soils

Soil	Acres	Per cent	Soil	Acres	Per cent
Miami loam	66,112		Plainfield loamy sand	5,824	1.7
Rolling phase	9,344	24.4	Brookston silt loam	3,968	1.1
Mottled-subsoil phase	8,960		Fox gravelly sandy loam	3,136	.9
Muck and peat	45,824	13.2	Swamp	3,136	.9
Miami sandy loam	38,656	12.6	Coloma loamy sand	2,752	.8
Rolling phase	4,800		Bellefontaine loam	2,432	.7
Fox sandy loam	37,440	10.8	Warsaw sandy loam	1,856	.5
Brookston loam	28,736	8.3	Clyde silty clay loam	960	.3
Bellefontaine sandy loam	21,056	6.1	Genesee silt loam	768	.2
Maumee loam	12,416	5.4	Crosby silt loam	320	.1
Light-colored phase	6,400		Genesee sandy loam	256	.1
Miami silt loam	15,616	4.5	Gravel and clay pits	192	.1
Warsaw loam	11,264	3.3			
Fox loam	7,424	2.1	Total	346,240	
Clyde loam	6,592	1.9			

MIAMI SANDY LOAM

The surface soil of the Miami sandy loam when dry is a moderately dark grayish brown, loose sandy loam with but little organic matter. Small stones and gravel are usually present, but are not commonly abundant. The upper portion of the subsoil, to a depth of 15 or 20 inches, is a lighter-colored sandy loam, grading into a stiff, brown clay loam, often into a heavy loam with much coarse material. Usually the substratum is a heavy calcareous till. Both soil and subsoil are acid to litmus paper.

In the vicinity of areas of Bellefontaine sandy loam there is usually much stony material in both soil and subsoil, and gravel may form the deep substratum. This may also be the case where areas of Miami sandy loam join areas of Fox sandy loam. The Miami sandy loam mapped between Warsaw and Pierceton is a coarse sandy loam, and generally very stony. Between Pierceton and Sidney the type is finer textured, and usually the dark-brown subsoil occurs at shallow depths and is very heavy. There is a great deal of variation in the depths of the sandy loam, and patches of loamy sand usually occur on local elevated points. Throughout Monroe and Jackson Townships the Miami sandy loam is not very different from the Miami loam, both types occurring in local areas where definite lines of separation seldom exist.

The topography is generally rolling. The areas southwest of Warsaw and those between Claypool and Sidney are gently rolling to somewhat hilly in places.

Except in local depressions too small to map, all this sandy loam has good drainage. Occasional patches of coarse, loose sand are droughty.

The originally meager amount of organic matter has decreased in cultivated ground. The friability of the soil, however, insures good tilth under variable weather conditions. In slight depressions a dark loam generally occurs which is much richer in organic matter.

The yields of corn on this soil range from 35 to 50 bushels. Oats, wheat, and rye give returns comparable with those of the other upland types. Young clover may be affected by hot summer weather, but when once established it makes good growth. Its earliness, good drainage, and quick response to fertilizers render the type very desirable for tomatoes. Melons, sorgo (sweet sorghum), and Sudan grass do well where the soil is more sandy. Apple, cherry, and plum trees around house sites thrive quite as well as on heavier soils, but bluegrass and timothy are not so well suited to this soil.

Practically all of the type, except the wood lots, is cultivated. Farms consisting chiefly of this type range in value from $125 to $175 an acre.

Miami sandy loam, rolling phase.—The rolling phase of Miami sandy loam includes those areas of Miami sandy loam which are strongly rolling to hilly. These areas range in size from a few acres of steep hillside to several hundred acres of ridges, moundlike elevations, and sharp declines to lakes and muck beds. It is not practicable to show all these areas having strong relief; however, most of the larger ones are mapped.

The virgin soils of these areas are predominantly sandy, but there is much variation in texture and in depth to the heavier reddish-brown subsoil. In cleared land the variability has been increased by surface washing, so that the soil on many slopes is a brown loam, whereas that near the foot may be a deep silty loam. There is generally considerable gravel and stony material on these areas. On some of the more prominent elevations the soil type is Bellefontaine sandy loam.

Mapped areas of the rolling phase of Miami sandy loam include patches of Brookston loam. Along the drainage ways a soil of an alluvial character occurs in patches or occasionally forms level fields of several acres. Such areas are admirably adapted to pasturage, and are congenial locations for walnut, hickory, poplar, and elm trees.

Although most of the phase is better adapted to grazing than to tillage, cultivated crops usually give good returns. The shallow depth to calcareous material on steep slopes may explain their adaptability to clover. Much of the phase should be devoted to timber or to pasturage.

MIAMI LOAM

The surface soil of typical Miami loam consists of 6 or 8 inches of grayish-brown, friable, rather coarse-textured loam, which has a grayish cast in dry cultivated fields. This surface soil is underlain by 10 or 15 inches of pale-yellowish or light yellowish-brown loam, more silty than the surface soil. In the heavier variations it is mottled with gray and pale-yellowish spots, indicating imperfect oxidation. Below this is a layer of brown or slightly reddish-brown loam, somewhat compact in the lower part. At depths of from 30 to 40 inches, less compact loam is encountered, which is not so well oxidized or leached as the overlying material. At depths of from 40 to 50 inches, the material is usually calcareous; whereas that above is decidedly acid to litmus paper.

There are no very well defined boundaries between this type and the sandy loam and silt loam of this series. The loam in many instances represents simply broad gradation zones between areas of sandy loam and silt loam. There is generally more stony material on this type than on the silt loam. Bowlders were once very abundant in many places, but they have generally been removed.

Small areas of the Brookston soils and other dark-colored types are included in almost every mapped area of 40 acres or more.

The topography is irregularly rolling. In places, as in the vicinity of lakes and creeks, it is hilly. On the higher uplands remote from the larger lakes the surface is gently rolling to undulating.

All this type was originally forested, walnut, hickory, sugar maple, and oak being the dominant trees. Some land remains in wood lots but the greater part has been in cultivation many years.

Corn, wheat, oats, and clover are all most successfully grown. The average yields on this soil do not seem to differ greatly from those on the silt loam, but the loam is a little more satisfactorily managed under excessive rainfall. It endures dry weather exceptionally well if properly tilled, since it is retentive of moisture. The productiveness of the soil can be maintained by the methods recommended for the silt loam.

The price ranges from about $125 to $150 an acre for rolling land, and somewhat higher for the smoother land. Location, roads, and improvements are important factors in all instances.

Miami loam, mottled-subsoil phase.—The surface of the Miami loam, mottled-subsoil phase, is a very friable, fine-textured loam, 6 or 8 inches deep. Small stones and gravel are usually very numerous on the surface and occur throughout the soil, subsoil, and in the parent material. The normal color is grayish brown, but plowed fields often appear very gray on the higher ground. In the slight depressions the soil is darker colored, approaching the Brookston in surface appearance.

The subsurface is a silt loam or silty clay loam which is dominantly yellowish brown and mottled with rusty-brown and grayish colors.

At a depth of 18 or 20 inches the subsoil is usually a clay loam or heavy loam. At a slightly greater depth a somewhat compact zone is found which is more or less mottled with shades of light brown, pale yellow, and gray. Below this layer the material is usually less compact.

Carbonate of lime commonly occurs about 3 feet below the surface. The surface and subsurface layers are decidedly acid, the lower subsoil seems to be less so, but is seldom neutral, according to field tests.

This phase prevails in the low, gently undulating country in the northwestern part of the county. The individual areas are rather intricately associated with darker soils, few fields being found which do not include patches of the darker soils. In general, areas of this soil have less surface relief than the typical Miami soils.

The surface drainage is fair to good. The average water level has, undoubtedly, been lowered since the lands were brought under cultivation. This means the permanent betterment of any land that lies at an elevation 2 or 3 feet higher than adjacent darker-colored soils.

All of this phase was formerly timbered, but only a few wood lots remain.

Under good tillage, this is a productive soil. Most of it is not seriously affected by extreme seasonal conditions. The occasional flat spots, where the soil has a decidedly gray appearance, are most affected by wet weather.

Practically all of this soil is well-kept farm land, on which a rotation of corn, oats, wheat, and clover is generally practiced. Considerable improvement by means of open ditches and tile drains has been made in recent years.

The yields of corn range from about 30 to 50 bushels, with better returns in many instances. Oats and wheat of good quality are generally grown, and the yields are as good as on the upland types. Good yields of clover may be obtained on nearly all farms. Less difficulty is experienced in clover growing than might be inferred from the acid condition of the soil. Fruit and garden crops are generally grown.

Miami loam, rolling phase.—The surface of the rolling phase of Miami loam ranges from strongly rolling to broken. The differ-

ences in elevation in any locality seldom exceed 100 feet, and usually are less than 50 or 60 feet. Slopes too steep for cultivation form only a small proportion of the total area. In most instances these steep slopes are short, steep declivities along lake margins or the borders of muck beds. Elsewhere rounded ridges of irregular height and trend form the characteristic topography. Short ravines and rather numerous patches of mucky ground occur in many of the depressions. Where a stream traverses such a hilly tract, strips of brownish sandy sediments a few rods wide may be found. Patches of smooth ground, necessarily included, are narrow crests of ridges and occasional gently sloping strips of low ground bordering drainage ways.

Broadly considered, this soil is similar to the typical Miami loam, differing in depth and texture of the surface layers and in the degree to which oxidation and leaching has taken place in the subsoil. Except in the vicinity of some of the lakes, most of this phase lies in regions of heavy till where clayey subsoils prevail.

Some of this land is densely wooded; more of it, however, occurs as sparsely wooded pastures where bluegrass is the prevailing soil cover. Much of this land has been cleared, perhaps half, and is either in grass or is devoted to cultivated crops. Good returns of rye, wheat, oats, and clover are often obtained. As a result of a deficiency of organic matter in the soil, corn grows thin foliage and small ears, except in depressions where excellent yields are usually obtained.

Some small farms consist almost entirely of this rolling land. The lower price per acre, as compared with the smooth phase, constantly induces purchasers of limited means to attempt the improvement of this land, a few acres at a time, or as small farms. Highly productive ground is generally limited to nearly level spots. The small fields and variable surface conditions make the acre labor cost for tilled crops very high.

MIAMI SILT LOAM

The surface soil of Miami silt loam is a brown to grayish-brown silt loam, containing a rather high proportion of sand and usually some small stones. It is underlain, at depths of from 6 to 10 inches, by pale-yellowish silt loam which is slightly compacted, but which crushes easily in the hand. The lower subsoil is brown to light-brown silty clay loam or clay loam. At a depth of about 3 feet the material becomes lighter colored and slightly mottled with brownish gray and drab. Free carbonate of lime occurs at depths ranging from 30 to 40 inches below the surface; except in sandy areas, where it usually occurs at deeper depths. The surface soil and subsurface layer are usually acid.

In many places a compact zone occurs just below the light-yellowish subsurface layer. This is more commonly found on nearly level areas where the silty surface soil assumes a light tint when dry. In such locations the compacted layer interferes with underdrainage, and to some extent with capillary rise of soil moisture. On the flat tops of ridges and on slopes there are spots or patches of cold, whitish-gray soil which tends to pack under wet conditions. These spots

in many instances are well-developed Crosby silt loam, but they are usually too small to be indicated on the map.

The Miami silt loam is developed mainly on the undulating to gently rolling uplands of the southern part of the county. A smaller area lies along the county boundary east of Pierceton. The small area near Morris Chapel is essentially a heavy phase of the Miami loam, with some pronounced silt loam spots.

Nearly all of this soil is devoted to comon farm crops. It is a little later soil, and possibly more subject to injury by excessive rainfall than the Miami loam. Practically the same crops are grown on both soils. Miami silt loam responds well to manure.

As on other Miami soils, the foliage of growing crops is not commonly so heavy as on darker-colored soils; but the quality of grain is good. Most crops are a little later in starting than on the sandy loam and the loam types, but at the end of the growing season little difference is to be observed in the appearance of crops that are grown in fields in which several types of soil may occur.

It is estimated that the average yield of corn per acre on this kind of soil is about 40 or 50 bushels. In 1920 corn on this type matured from one to two weeks later than on the sandy loams of the Bellefontaine and Fox series. Both corn and wheat show marked improvement in yields on manured ground, or on blue-grass or clover land. Phosphate fertilizers are used on wheat, but not commonly on other crops. The yields of oats range from 25 to 60 bushels per acre. Not much trouble is experienced in obtaining good clover stands in normal seasons. Blue grass does better than on the sandy loam, and it is the dominant herbage in pastures, along roadsides, and in farmyards.

Practically all of this land is in well-improved farms. It ranges in value from $125 to $175 an acre.

CROSBY SILT LOAM

The surface soil of moist Crosby silt loam is light gray in color. When dry it assumes a lighter color and a more ashy appearance. The subsurface layer, to a depth of 10 or 12 inches, is similar in texture, but in many places it is slightly stained with yellowish colors. Between the depths of 12 and 24 inches there is usually a layer of compact, silty clay not easily penetrated by water. With increase in depth, the silty clay material becomes somewhat more crumbly, or assumes a more granular structure on drying, a property quite lacking in the layer just above it. The substratum is the yellowish-gray calcareous till common to the Miami type. Usually there is no carbonate of lime within 3 feet of the surface, all horizons being acid. Small ferruginous concretions commonly occur on the surface and are sparingly distributed throughout the subsoil.

The Crosby silt loam is not so extensively developed in Kosciusko County as in the counties farther south in the State.[2] A few areas of less than 100 acres each lie east of Etna Green, and several more of similar extent are found in the extreme southeastern corner of the county.

[2] See Soil Survey reports of Wells, Grant, and other counties of north-central Indiana.

The surface is level or nearly level, and consequently the natural drainage is poor.

Practically the total area of the type is under cultivation. It is not well adapted to corn on account of its lack of humus and its tendency to remain wet for long periods after heavy rains. In seasons of rather light but well-distributed rainfall the yields are comparable with those on the Miami silt loam. Oats on this kind of soil are more susceptible to seasonal variations than on the Miami and Bellefontaine soils. Wheat usually gives more satisfactory returns than oats. In all instances seasonal conditions, methods of tillage, artificial drainage, and quantity of fertilizer applied are even more important factors in crop production than on the darker-colored types. Red clover is grown, but it does not do well on the lightest-colored spots. Blue grass and white clover thrive along roads and ditch banks, and extend into pastures, but to a less extent than the weeds and small grasses which can endure wet, acid soils.

In most of the fields in which this type occurs, more or less tile drainage has been installed, which, with road ditches, has greatly improved the general drainage. In most cases the land comes into condition for tillage rather slowly after heavy rains, owing to the slowness with which water moves through the soil. The value of this land is generally somewhat lower than that of adjoining Miami soils.

BELLEFONTAINE SANDY LOAM

The surface layer of Bellefontaine sandy loam in cultivated fields is a rather coarse and loose sandy loam, very light grayish brown when dry, but assuming a pronounced brown color when wet. It usually contains much gravel and many small rounded stones, but rarely any large stones. The subsurface material is somewhat finer in texture than sandy loam. The color is generally some shade of yellowish brown, often approaching light buff in the more silty variations. At a depth of about 20 or 24 inches, the subsurface sandy loam is underlain by a reddish-brown gravelly sandy loam, or in many places by a clay loam. The clay particles and iron oxides here present in large quantities, form a matrix for the stony material. This mass may be so firm when dry that farmers speak of it as "hardpan." It is by no means impervious to water and has fairly good moisture-holding properties. The thickness of the reddish-brown layer is usually less than 2 feet, although it varies considerably. Sometimes it extends several feet downward as wedges and columns into the substratum. The substratum consists of gray, loose, coarse sandy gravel, very calcareous. (Pl. XXXI, fig. 2.) The soil material immediately above this gravel is free of lime carbonate, except for an occasional fragment of limestone. It is neutral or slightly alkaline, but the surface soil and yellowish subsurface are distinctly acid to litmus paper. Virgin woodland soil has a few inches of dark humus-laden sandy loam, but cultivated land has very little organic matter.

The original forest growth included much red oak and sugar maple, with less elm and ash than are found on the heavier upland types.

Much of the Bellefontaine sandy loam is too rough to permit convenient tillage. As a rule the differences in elevation in any

particular locality do not exceed 40 or 50 feet. In small areas the surface configuration may range from undulating ridges to short, steep, stony slopes bordering a lake or marsh. The areas associated with the Fox soils are generally the broken margins of high terraces overlooking a lake. The larger areas 2 to 3 miles east of Warsaw include much comparatively smooth land. Those south of Lake Winona are high terraces with rougher land on the margins. The isolated areas in the central and southern parts of the county include low, gravelly ridges and hills near the drainage ways. The areas near Webster Lake are chiefly ridges with tillable land on the tops. The largest area extends for a distance of about 9 miles, from a point 3 miles north of Warsaw, in a more or less irregular belt, nearly to the Marshall County line.

Although the type is susceptible to drought, all except the most sandy variations endure dry weather remarkably well, provided frequent shallow tillage is given. The brown "clayey" spots on eroded slopes are fertile, but are difficult to keep in good tilth. Recently cleared land, or ground that has previously been in sod or has received manure, will, with good tillage, produce a crop of corn under very light rainfall. This was evident during the dry summer of 1920, when some fields a few miles south of Warsaw produced an estimated yield of about 30 bushels per acre.

The yields of corn for the type are from 25 to 40 bushels per acre, the early-maturing strains giving the higher yields on well-managed farms. Rye does well on practically all areas of this type. Wheat and clover do better on the heavier areas and on the darker and more loamy soil in local depressions. Young clover invariably suffers if July and August weather is exceptionally dry. Blue grass starts very early, but soon shows the effects of summer heat. Tomatoes do well on this type, and some melons and cucumbers are raised. Cherry trees thrive, and many old apple orchards are bearing regularly. Small fruits do not do well, except in spots where the type grades into the Brookston soils. Eighty per cent or more of the total area of this type has been cleared, a considerable acreage being used only for pasture.

The agricultural value of most of this land ranges from about $75 to $100 an acre. Lands near lakes and towns are held at much higher prices.

BELLEFONTAINE LOAM

The dry surface soil of the Bellefontaine loam is a grayish-brown loam in which there is usually a high percentage of silt and also much rather coarse material. At a depth of about 6 inches, brown clay loam occurs which contains considerable coarse sand and some gravel. The zone between 12 and 24 inches below the surface is a distinctly reddish-brown, sticky, sandy clay containing more or less stony material. The lower subsoil is gravel or gravelly, stony material so slightly weathered that it still contains much carbonate of lime.

Although the type is confined to morainic deposits in which coarse, calcareous gravel and small stones form a large proportion of the material, there are many places where silt and clay are important constituents of the soil and subsoil, either as original components of the parent material or as decomposition products

derived from the less resistant rock fragments. In such places the subsoil is heavier but not compacted. There are also places where the surface soil is a sandy loam, resembling that of the Coloma loamy sand, and the subsoil is a stiff, reddish, sandy clay or a rather heavy gravelly clay or clay loam. Nearly everywhere the material above the lighter-colored calcareous substratum is well oxidized and leached, being neutral or only slightly acid in reaction.

The largest areas of Bellefontaine loam lie a few miles northwest of Warsaw. Here they are associated with the Bellefontaine sandy loam, where the two types grade into each other. The loam has a somewhat smoother topography, with numerous short abrupt slopes and gravelly ridges. Nearly all of it is in cultivation. The crop yields and soil-management methods are similar to those on the smoother areas of Bellefontaine sandy loam.

COLOMA LOAMY SAND

The Coloma loamy sand is characterized by a brown, rather coarse, loamy sand 8 or 10 inches deep, underlain by yellowish-brown sand. At depths varying from 30 to 40 inches, the material is usually a yellowish-brown, stiff clay loam or sandy clay, which extends to a great depth.

The organic content is low, and it usually colors the sand only to a depth of a few inches. The percentage of silt and clay particles distributed through the sandy layers is not usually more than sufficient to cause feeble coherency when the mass is moist. On occasional patches the soil is so light textured that the surface sand drifts or "blows" badly during dry, windy weather.

The soil to a depth of 40 inches or more is acid in reaction. The topography of the larger areas of this soil strongly indicates that wind has been the chief factor in the accumulation of the sand. Low, smoothly rounded ridges and mounds prevail, seldom rising more than 20 or 30 feet above the adjacent depressions. The loamy sand is deeper, as a rule, on the higher knolls, whereas on the slopes it may be so shallow that the stony till is more or less in evidence. In the depressions the soil is darker colored and has a heavier subsoil. All the larger areas include these variations. The small areas are commonly low, evenly rounded mounds or ridges rising somewhat above the general level of the adjacent uplands. The long narrow areas are low ridges varying from 10 to 20 feet in height. Some of these extend for considerable distances across the Fox sandy loam and associated types.

Although the underlying till is the chief moisture reservoir, the loamy sand itself has considerable capacity for holding water. Since, under like conditions, this type of soil yields to plants a much higher percentage of its moisture content than a heavier soil, and in it plant roots penetrate deeply, this soil has a better crop-producing power than may be inferred from its description. Extremely droughty spots are generally confined to the highest knolls and the crests of ridges, where the sand is coarser and deeper.

The soil responds readily to applications of commercial fertilizers or farm manure. Adding organic matter by turning under bluegrass or clover sod increases the yields of two or three following

crops. Since this is an early soil, crops often escape the effects of late summer droughts.

Rye gives more satisfactory returns than oats or wheat. Ordinarily corn does not do well, since it varies greatly in rate of growth and yields, according to local variations in the character of the soil. This is also true of clover, which may fail, except in the depressions. Good stands, however, are often obtained, and the yields are nearly as high as on other light-colored soils. In the lake region watermelons and cantaloupes are extensively grown. Sudan grass, sorgo (sweet sorghum), and soy beans do well, and tomatoes are grown for the canneries. Many thrifty orchards are located on this soil. Cherry and peach trees grow well on the higher ground, and plums find the richer soil of the depressions very congenial.

The maintenance of the supply of organic matter and the conservation of soil moisture are the first essentials in the successful management of Coloma loamy sand.

Rye, followed by two years of clover and grass, and then corn, seems to be a practicable rotation, and one that is practiced regularly by a number of farmers. Growing rye as a winter cover crop is advisable. It may follow corn or a truck crop. The great need of organic matter requires the greatest possible return of crop residues to the land. Soy beans, rape, and cowpeas make a feeble growth as interrow crops on account of a lack of moisture. When grown for the grain or for fertilizer purposes they alone should occupy the land.

This kind of land, in farms, is valued at about $100 an acre; as unimproved land it can be bought for considerably less.

BROOKSTON LOAM

The surface soil of Brookston loam is a dark grayish-brown, friable loam to silt loam with a moderately high content of organic matter. The depth is variable. Usually at depths varying from 10 to 20 inches a much lighter-colored loam or clay loam is found, in which dull shades of brown and yellowish brown prevail. Lower down the material has lighter colors and is less oxidized. The texture and structure of the soil and subsoil are generally favorable with respect to moisture conditions. The surface soil and the upper part of the subsoil are acid to litmus. The lower subsoil seldom contains carbonate of lime, though it may occur at a depth of about 40 inches or more.

The Brookston loam includes the dark grayish-brown soils commonly found in the local depressions of the uplands. These areas range in size from slight sags of a fraction of an acre to rather widely and irregularly extended tracts of 100 or 200 acres.

All this land requires artificial drainage for cultivated crops. As a rule no very great number of laterals are required, since the water moves very freely through the subsoil. The general lowering of the ground-water level throughout the uplands has resulted in much drier conditions in most of these depressions than formerly prevailed. Many of the wood lots located on these areas owe their preservation to the poor natural drainage. Elm, ash, white oak, and post oak are common trees in such locations.

This type of soil, when drained, is well adapted to all the ordinary farm crops. Clover and corn do well under a wide range of weather

conditions. Poor yields are not common on the carefully managed areas. The irregular shape of the majority of the areas prevents separate cultivation that would be desirable in many cases. The occurrence of this fertile soil, even in small or irregular areas, enhances the value of farm lands.

BROOKSTON SILT LOAM

The Brookston silt loam differs from Brookston loam chiefly in the more silty character of its surface soil. In many instances the surface layer is a mellow silt loam with the smooth "feel." There is usually but little sand or gravel in the surface soil, and the silty clay loam subsoil, mottled with brown and yellowish colors, contains no stony material, except in the lower part.

Small areas of the type occur in the central and southern parts of the county, in local depressions on the uplands.

Artificial drainage has been provided in most places, and all this land is under cultivation. In many places there has been considerable washing upon these areas of silty material from the surrounding uplands. This soil furnishes to crops a good supply of moisture, owing to the presence of a water-bearing substratum a few feet below the surface. Both the surface soil and the subsoil are acid to litmus. In some instances carbonate of lime is found at a depth of about 3 feet, and calcareous material occurs deeper down.

This type meets the requirements of corn, clover, alfalfa, and timothy wherever good drainage has been provided. Wheat and oats make more vigorous growth than on the Miami and Fox soils, and fertilization is not so necessary, although barnyard manure may be beneficial to corn.

Since the Brookston soils are so highly esteemed for corn, the price of any farm on which they occur is enhanced to a considerable degree. The present value of farm land consisting largely of these Brookston soils is about $150 per acre.

CLYDE LOAM

The surface soil of the Clyde loam, 10 to 15 inches deep, is usually a black, mellow loam or silt loam, rich in organic matter and containing but little stony material. The upper subsoil is a stiff clay loam or often a silty clay in which light gray is the dominant color and a few dull-brownish iron stains are present. This material has joints which facilitate underdrainage and aeration wherever the originally high water table has been permanently lowered by drainage. The lower subsoil is a light-gray or, often, a bluish-gray clay, with some yellowish or brownish mottling. The mottlings are not so noticeable as in the Brookston soils.

The Clyde loam occurs a few miles west and northwest of Leesburg, being closely associated with the Brookston loam. The surface level of these areas is usually slightly lower than the areas of Brookston soils, so that the main drainage ditches are usually cut through the Clyde areas. Nearly all this land is now artificially drained. In some places, however, additional tile drains would be beneficial. Practically all is in cultivation.

This soil is admirably adapted to corn, clover, and timothy. Where the water table is below 3 or 4 feet and overflows from the ditches are not frequent, alfalfa does well. This soil tends to "heave" during changeable winter weather. Very often this heaving injures the fall-sown grains. The present (1922) value of this kind of land may be placed at about $150 an acre.

CLYDE SILTY CLAY LOAM

The surface soil of Clyde silty clay loam is a deep, black clay loam or silty clay loam, rich in organic matter. The subsoil is a heavy, silty clay in which bluish gray is the dominant color. It is a rich soil, and it has not been under cultivation so long as most other dark-colored types.

A body of typical Clyde silty clay loam occurs about a mile southeast of Dutchtown in Tippecanoe Township. Other areas are small, and do not have so heavy a surface soil. Some areas include a phase of the Brookston loam, the Clyde soil occurring in the central part of the depressions.

The type is admirably adapted to corn, clover, and timothy. Alfalfa will do well on well-drained areas. Most areas are hardly safe for fall-sown crops, on account of possible overflows. Cabbage and other truck crops are very successfully grown in small quantities.

PLAINFIELD LOAMY SAND

The Plainfield loamy sand is moderately dark grayish-brown, loamy sand, a few inches deep, underlain by sand of similar character, but lighter in color. Below a depth of about 18 inches, the material usually consists of light yellowish-brown, coarse to medium sand, in which there may be more gravel than in the surface layer.

In a soil of such coarse texture with gravel substratum, drainage is thorough, oxidation is well advanced, and very little organic matter has accumulated. The soil is acid to litmus paper, and there is no evidence of carbonate of lime at depths of from 30 to 40 inches.

The type has developed as small bodies on the higher terraces. Many patches of this soil are included in mapped areas of Fox sandy loam; these included patches, as a rule, being low, smooth mounds with little or no gravel. Plainfield loamy sand, being a droughty soil, is better adapted to such crops as rye, sorgo, and Sudan grass, than to ordinary farm crops. Early truck crops do well, and watermelons are very successfully grown.

On the map this type includes several patches of low, sandy lands on the margins of lakes. On the west side of Lake Winona and near Center Lake these patches are coarse sandy loams and sands lying only a few feet above the lake levels. They are under cultivation and, for the most part, well adapted to melons, tomatoes, and other truck crops, as well as Sudan grass, sorgo, and some varieties of soy beans. An area near Etna Green is nearly all cleared and is used largely for producing hay and pasturage. The "island" upon which the lower part of the town of Winona Lake is located, consists largely of one or two feet of coarse sand and gravel underlain by muck.

FOX GRAVELLY SANDY LOAM

The Fox gravelly sandy loam is very much like Fox sandy loam, differing only in having a higher percentage of gravel in the surface soil and subsoil.

The Fox gravelly sandy loam includes the margins of the higher terraces where the degree of slope and the elevation above adjacent lands render such areas largely untillable. The narrow areas overlooking Tippecanoe and James Lakes rise from 20 to 40 feet above the shore line, and those on Tippecanoe River and near Webster Lake have even greater elevations. Some morainic mounds are also included. The depth of the surface soil is quite variable. As a rule, the heavier subsoil is sufficiently retentive of moisture to make these slopes fairly well adapted to blue grass and clover. Spots that are very droughty, because of great depth of loose sand and gravel, are not common.

The original forest has been largely removed, and these lands are either included in cultivated fields or are used for pasture. The areas near Warsaw are gravelly ridges and knolls which afford good sites for houses. The scattered areas of the type very much resemble Bellefontaine sandy loam. In many places the value of the land is greatly enhanced by its suitability for summer cottages or recreational purposes.

FOX SANDY LOAM

The surface soil of Fox sandy loam, to a depth of about 6 inches, is generally a medium to coarse sandy loam, in many places being a coarse-textured loamy sand. The content of organic matter is low, so low that it has but a slight effect on the physical properties or the color of the soil, particularly on the cultivated areas. The color on virgin areas is usually a rather dark shade of brown in moist soil, whereas on dry cultivated fields it is dull grayish brown. The subsoil, beginning at depths of from 6 to 18 inches, is a lighter-colored sandy loam slightly more compact and heavier than the surface soil. The subsoil grades downward into a reddish-brown, coarse-textured loam or sandy loam. This lower horizon varies in thickness, and it lies at depths ranging from 20 to 30 inches below the surface. This deeper material contains no lime carbonate, it is well oxidized, and it is very sticky when wet. The clay rather firmly cements the coarse grains and pebbles on drying, but there is rarely any "hardpan" development. The structure and texture of the soil and subsoil are usually favorable in respect to moisture conditions.

At a depth of 30 or 40 inches loose, gray, calcareous gravel occurs and the line of contact between this and the reddish-brown layer above is very distinct. There are more or less gravel pebbles and small stones on the surface and distributed throughout the soil and subsoil.

The Fox sandy loam is the prevailing type of soil on the level areas near the larger lakes and along their principal outlets. Smaller areas are found in the northwestern townships, associated with the Maumee soils.

Areas of this soil mapped along Turkey Creek are but slightly higher than the immediate banks of the stream, and they have a slightly undulating topography. Patches of Fox loamy sand and Warsaw sandy loam are included in mapped areas of Fox sandy loam, the Warsaw soil generally occurring in depressed spots where some organic matter slightly darkens the surface soil. Most of these included areas are comparatively free from gravel and are evidently underlain by sand.

Near Milford light variations of the type predominate. The areas south of Webster Lake are very gravelly, and they merge into Bellefontaine sandy loam. Near Oswego the type is predominantly light textured, and mapped areas include many spots of Fox loamy sand. Toward the south and southwest the type gradually becomes fine textured, the reddish-brown gravelly clay substratum is more definitely defined, and the type grades into Fox loam. All these gradations are rather broad, and map boundaries between these different types are more or less arbitrarily placed.

Along the Tippecanoe River, the sandy loam is coarse textured and generally gravelly. This is especially the case on most of the slopes near the river and on elevated areas. Small areas of dark soil similar to the light phase of Maumee loam occur in many places. The area of Fox sandy loam on Eel River is a high terrace, and in most places the soil contains much fine gravel.

Practically all the Fox sandy loam is under cultivation. Dry weather affects crops to a less degree than may be inferred from the description of the soil. However, it does not have the moisture reserve of types in which clayey materials form the subsoil and lower substratum. The more sandy soils are droughty during ordinary dry seasons. In 1920 the rainfall was ample until about June 1, and during the three following months it fell much below normal. Corn and oats gave satisfactory yields that season. The wheat failure was due to other causes; but clover, blue grass, and late garden crops were seriously affected.

The yields of corn range from 25 to 40 bushels; and of oats, from 25 to 50 bushels. Rye does well. Winter wheat on this land generally suffers little injury from "heaving" of the soil or from coverings of ice. Liberal fertilization of wheat is necessary, and yields of from 20 to 25 bushels are often obtained. Clover on this sandy soil requires more summer rainfall than on the heavier soils. The type is not so well adapted to blue grass and timothy as are the heavier soils. Alfalfa has been tried, but not with any marked success. This is also true of attempts at growing soy beans or rape in corn, for there is not always sufficient moisture for two crops. Sudan grass and sorgo make very good yields, even under adverse seasonal conditions. Sorgo for sirup, tomatoes, cucumbers, watermelons, sweet potatoes, and all early garden truck find this a congenial soil.

As a very general estimate, this kind of land is valued at about $100 an acre. Well-improved and desirably situated farm lands command considerably higher prices. Residential sites on the lake shores enhance to some degree the value of adjacent land.

In sections 26, 35, and 36 of Scott Township, the Fox sandy loam has somewhat poorer drainage than in other places. Here the soil

is characterized by gray to brown surface soils and mottled gray, brown, or yellowish-brown subsoils. The surface is flat to very slightly depressed. The water table of these areas was formerly higher than it is now, having shared in the general lowering of the ground-water level of the region.

Similar variations of the type are found in many of the smaller areas near Mount Tabor Church. They are especially noticeable in the small, low "islands," surrounded by black soils. On many of these islands patches of gray to pale-yellowish soils occur which have the mottled subsoil indicative of long-continued saturation. In most instances these spots are of such small extent that they are not shown on the map.

With possible exceptions of the Fox sandy loams having the very lightest gray surface soils, all of this light-colored variation is greatly improved by artificial drainage. Though this soil which requires drainage is not quite so warm and early as the brown or well-oxidized soil, it usually grows good crops.

FOX LOAM

The Fox loam is a brown loam 6 or 8 inches deep, which grades downward into a somewhat heavier loam or silty loam of light-brown color. The lower subsoil usually varies from a reddish-brown loam to clay loam in which some gravel occurs. At depths varying from 36 to 40 inches the percentage of sand and gravel increases, and at a slightly greater depth occur the upper layers of the gravel substratum. Oxidation has been very uniform throughout the loam material. Calcareous material rarely occurs within 40 inches of the surface. The soil and upper subsoil are distinctly acid to litmus paper.

The largest areas of this type occur a few miles north and northeast of Warsaw. They are high terraces of nearly level land with but little waste land due to surface inequalities. Toward Oswego the comparatively heavy soil very gradually changes to a sandy loam. Near Monequet the type is a silty loam. The areas west of Warsaw are high, gently sloping lands with a comparatively deep, heavy subsoil, particularly as the uplands are approached. The small areas elsewhere are more variable in character of soil and surface features, but are usually heavier than Fox sandy loam.

This type has good natural drainage, deep aeration, and excellent moisture-holding properties. Crops grown on it can endure extreme weather conditions remarkably well, and the soil may be cultivated under a wider range of moisture conditions than the heavier upland types. The more silty soil will clod to some extent, but ordinarily the typical soil maintains good tilth under field conditions.

The original tree growth included much fine walnut, poplar, and oak. Excepting occasional wood lots, all the land is now in cultivation. The average yields of corn range between 40 and 50 bushels per acre. Higher yields are obtained where manure is applied or where the land has been previously devoted to pasturage for some years. Wheat yields vary from 20 to 30 bushels in normal seasons. Acid phosphate is used on wheat and in many instances on corn. Good crops of oats, rye, and minor crops are grown. Clover does

well, and little trouble is experienced in securing a satisfactory stand. The present value ranges from $150 to $200 an acre.

WARSAW SANDY LOAM

The small areas of Warsaw sandy loam near Milford are level lands, the soil being a coarse sandy loam to light loam containing sufficient humus to give it a rather dark color. The subsoil may vary from a yellow, gravelly sandy loam to a sticky, sandy clay, which grades into sand or gravel at a depth of 25 or 30 inches below the surface. On slight elevations the soil is generally more sandy than on the level areas or in the slight depressions. In the latter it is often a dark-brown loam well supplied with organic matter, underlain by a somewhat mottled, sandy loam subsoil. The areas south and southwest of Salem Church are low ridges in the larger areas of Warsaw loam. Here the soil is a dark-brown, loose, sandy loam with a rather light subsoil. In general, this type as mapped includes various phases of the Warsaw and Fox soils, with some level spots of Maumee loam, light-colored phase.

All the type is in cultivation. The crops adapted to the lighter-colored soils are practically the same as those that are grown on the Fox sandy loam. Ordinarily the type is a little more desirable for corn, clover, and small grain, on account of the higher content of humus. The level areas are very well adapted to all field crops. The drainage conditions of these flat spots has been greatly improved by the general lowering of the formerly high water table.

WARSAW LOAM

The surface soil of the Warsaw loam is a dark-brown to brownish-black, friable loam, in which there is usually a little coarse sand and some gravel. At a depth of 8 or 10 inches it grades into a chocolate-brown loam which, with depth, becomes more sandy. Below 18 or 20 inches there is generally a marked increase in the proportion of coarse material, so that the lower subsoil is a reddish-brown gravelly sandy loam. The underlying material is a calcareous sand and gravel, very similar to, if not identical with, the substratum of the Fox sandy loam.

Both soil and subsoil are acid to litmus paper. Limestone pebbles are sometimes found within 3 feet of the surface, but the highly calcareous gravel lies a little deeper.

As mapped, the type includes patches of a sandy loam containing less organic matter and having the brown gravelly subsoil occurring at a depth of 10 or 15 inches. The darker-colored and deeper soil in slight depressions may be a silty loam with a rather heavy subsoil to a depth of 18 or 24 inches. In nearly all departures from the type the soil tends toward a rather coarse sandy loam.

Occasional spots require open ditches or tiles; but generally the natural drainage is good, owing chiefly to the gravelly substratum. This gravelly substratum also insures deep and effective aeration.

The greater part of the fine farm land between Clunette and Leesburg consists of this type of soil. It also extends a few miles east and north of Leesburg. It is locally known as "the prairie," but portions of it were forested when the first settlements were made.

In the remaining wood lots, elm, ash, and sugar maple are the dominant trees. For the most part the organic matter of the soil has been derived from the herbaceous vegetation that formerly covered all this level land. This old "humus" imparts the dark color and greatly favors the development of good tilth.

The Warsaw loam is an excellent corn soil. The yields average between 40 and 50 bushels per acre, with frequent returns of from 60 to 70 bushels. The yields of wheat reported by farmers range from a few bushels to 30 or more per acre. Unfavorable seasons and insect pests undoubtedly account for these extremes, for the type seems well adapted to wheat. Oats usually do well, and an undesirably rank growth of straw seldom occurs, except in low spots.

Reports of farmers concerning clover are somewhat variable. It is often difficult to get a satisfactory stand, particularly if the plants are small when winter sets in. It is possible that "heaving," or the effects of freezing and thawing during the winter months, may be more pronounced on this dark-colored soil than on the light-colored soils. Weeds are also more troublesome on the darker soils. The soil is not exceptionally acid. Less effort is made to raise clover on this type than on most other soils. On the majority of farms the proportion of land annually devoted to grain is higher than on the farms consisting of lighter-colored soils.

The farms average somewhat larger than in the formerly timbered sections. In general they are well improved. In recent years an increasing number is being operated by tenants. The present value of improved land ranges from about $175 to $200 an acre, but some well-improved farms near towns are held at prices ranging from $200 to $250.

Cultivation and the operation of natural agencies are tending to change this type to Fox loam or, in case of the more sandy variations, to Fox sandy loam. Leaching and oxidation are rather active, owing to the gravelly substratum. Exhaustion of the organic matter is being accelerated by excessive cropping to grain.

MAUMEE LOAM

The Maumee loam is a black, mellow loam, from 6 to 12 inches deep. It contains a high percentage of plant remains, chiefly in the form of well-decomposed material like that contained in black prairie soils. It usually contains some gravel, but no stones. The subsoil is generally a clay loam, which is inclined to be stiff but not so compact as to prevent free movement of moisture. The subsoil is colored gray and bluish gray with dull shades of brown running through it. With depth, the bluish-gray color becomes more pronounced, so that the lower subsoil is a light-colored silty clay or clay loam. Calcareous gravel forms the substratum, and locally the lower part of the 3-foot section contains some free lime.

The largest areas of this type are in the northwestern part of the county, where they form a large proportion of the level black lands which have been reclaimed from a former semimarshy condition. Drainage ditches from 10 to 20 feet in width and 10 feet or more in depth are common on most areas of this and associated types. As a rule many laterals or many lines of tile have not been found to be necessary. Isolated sags and low marshy spots often require

outlets to the main ditch, but the permanent lowering of the water level may be observed on all areas of this type.

The Maumee loam is a highly productive soil, well adapted to corn and clover. The yields of corn range from 50 to 75 bushels per acre, and clover usually produces good yields almost regardless of weather conditions. Wheat is sometimes injured by "heaving," caused by alternating freezing and thawing during winter months. Otherwise wheat does well on this soil. Oats make a rank growth, and they occasionally lodge in wet seasons.

The type is well adapted to sugar beets. On this soil is produced a large proportion of the beet tonnage annually grown in this county. Onions, cabbage, potatoes, and most root crops do well.

The soil is not only very fertile but it will doubtless endure cropping for a long period. The abundance of organic matter and the character of the subsoil indicate a good soil. It also receives some sediments from occasional overflows of the ditches.

The value of this land ranges from $150 to $225 an acre, the latter price being for exceptionally well improved farms.

The areas of dark silty soil on the lower course of Turkey Creek are mapped as Maumee loam. Here the soil is characterized by a very high content of organic matter and the presence of bog-iron stains and mottlings. The subsoil is usually variable in structure and texture, alternate layers of gray sand and black mucky sand or loam often occurring within a depth of 3 feet. In places much ferruginous material is present, as indicated by the rather conspicuous mottlings in the subsoil. The enlargement of the creek channel and the consequent improvement in drainage renders most of this soil tillable. This land is subject to overflow, but is reasonably safe for most crops. Good crops of corn, sugar beets, clover, and timothy are produced.

Maumee loam, light-colored phase.—In its typical development the surface soil of the Maumee loam, light-colored phase, is a dark-colored, coarse-textured loam containing considerable organic matter. The depth of this surface layer is variable, but at less than 18 inches it grades into loam or clay loam, mottled with gray and brownish colors. At a depth of about 30 inches more sandy material is usually found; and lower down, very coarse gravel and sand form the substratum. The soil is acid, and no calcareous material is found within 2 or 3 feet of the surface.

The soil texture and structure are favorable to good moisture conditions. Formerly the water table was high, or at least more or less variable, having a tendency to saturate the soil frequently well up into the surface layers. The present drainage conditions are better, being due in part to a general lowering of the water level on the flat lands where this phase occurs. Nearly all the phase now has good drainage and is in cultivation.

The areas mapped in the northeastern part of the county are associated with Fox sandy loam. These areas are nearly flat and lie at slightly lower levels. Under natural conditions the ground water of these areas often came nearly to the surface, and there were long periods when the land was too wet for tillage. After the larger ditches were constructed the water table rapidly and permanently lowered several feet.

In places dull brown is the prevailing color of the surface soil, with many small ashy-gray spots. Some light sandy spots are included in mapped areas of this phase, resembling the Fox sandy loam, though they are not so well supplied with humus. The small areas occurring in the Fox sandy loam along the Tippecanoe River are generally coarse in texture and rather variable in depth. However, they give higher average yields than the lighter-colored soil. Other small areas are found near Milford and Syracuse.

This phase of the type has a texture and structure favoring easy cultivation, and, wherever satisfactory drainage has been provided. the soil is productive.

GENESEE SANDY LOAM

The Genesee sandy loam consists typically of a surface layer, from 8 to 10 inches deep, of brown to dark-brown sandy loam underlain by a lighter-brown sandy loam or loamy sand.

Occasional patches of sandy sediments along the smaller streams resemble the Genesee sandy loam, and hence are included with this type.

Along the Eel River there are some patches of brown sandy sediments, laid down for the most part when the river bed had a somewhat higher elevation than at present. They lie from 10 to 20 feet above the bottom of the present channel, so that recent overflows are not frequent or of long duration. Some of these areas are essentially bench lands, and the drainage conditions and character of the soil are similar to those of the Fox soils, although no very distinct characteristics have been developed in the soil. Most of these small bench lands are in cultivation and produce fair yields of corn, oats, and minor crops.

GENESEE SILT LOAM

The Genesee silt loam consists of dark-brown silty alluvium underlain by a lighter-brown material of varying texture. Along Plunge Creek the subsoil is generally sandy material.

These areas are mostly narrow and are bounded on each side by steep slopes varying in length from 10 to 30 feet. The crooked channels wind through them in such a manner that tillable patches are not very common. The occasional wider areas are dark-colored silty soil with a heavier subsoil, although sand may occur at somewhat greater depth and thus favor underdrainage.

The cultivable areas are confined to the occasional expansions of the bottom land, the narrower parts being used for pasture. Blue grass and white clover thrive where the ground is not shaded.

SWAMP

Swamp includes alluvial soils of such variable character that no classification is practicable. The areas mapped as Swamp on Tippecanoe River above Warsaw are mostly low flats, not more than a few feet above the surface of the water. Near the river bank mucky soils over gray sandy subsoils predominate, with some slightly higher spots of brownish sand. There are also occasional patches of rather deep Muck near the channel. In some instances more or less inferior

timber growth covers the shallow Muck, and on the sandy spots elsewhere coarse grasses and reeds form most of the vegetation. The pasturage value is inferior to that of the upland. Along the lower course of the river in this county Swamp includes more or less mucky soils, and much alluvium that approaches the Genesee silt loam and sandy loam in character. Occasional small fields are cultivated, but most of this land is in wooded pastures. Along the small streams variable conditions prevail, but little of the ground is suitable for any purpose except forestry or pasturage.

MUCK AND PEAT

The greater part of all the organic soils of Kosciusko County may be termed Muck, for the reason that the surface layers in most areas consist of black, well-decomposed, and finely divided plant remains and not of brown or darker-colored material in which the original plant structure is more or less discernible—the essential characteristics of Peat. This preponderance of Muck over Peat is due in a large measure to comparatively recent changes in drainage whereby the level of the ground water, formerly high, is now several feet below the surface. Above the water table oxidation has been very effective; below it the materials remain practically unchanged. These recent changes have progressed more slowly where the water level has stood very close to or at the surface the greater part of the time. In such locations the present plant associations are similar to those that occupied all the "swamps" before artificial drainage became so generally effective. To the organic deposits in these swampy areas the name Peat may be applied as a convenient although not necessarily precise term to distinguish them from better drained areas in which the soil conditions and the vegetation are so different.

A large proportion of the Muck is devoted to field and truck crops, and much of the remainder is well set to blue grass and has a high value for pasturage, especially where there is an appreciable content of mineral matter. Considerable areas retain much of the native grasses and sedges, with more or less admixture of redtop. Muck on which grow large elm, ash, and red maple occurs along the Tippecanoe River, but elsewhere the forested Muck is of rather limited extent. Most of it has been reclaimed and is now in cultivation. In such cases the woody débris has largely disappeared, and the finer material has a somewhat grainy or "lumpy" structure, and under good tillage is mellow but not loose or "chaffy." This may be termed "woody muck."

In many places the Muck has a dark to black, nonfibrous subsurface layer ranging in thickness from a few inches to several feet. It somewhat resembles an impure coal, breaking with a smooth fracture, and on drying is hard and somewhat "rubbery." This material appears as small hard flakes or minute chips in the fibrous peat material. It is sometimes called "colloidal peat."

The black finely divided Muck, derived chiefly from grasses, assumes a rather loose or "chaffy" condition when dry and is well oxidized or is in an advanced stage of decomposition. Below the ground-water level it appears as a brown or reddish-brown, coarse,

fibrous mass in which stems, roots, and other parts of plants may be easily recognized. This is fibrous peat, in many places very pure, in others mixed with colloidal and macerated peat.

In many places along ditch banks these three kinds of material may be seen as distinct layers. In the surface soil much admixture of material usually occurs, especially in cultivated ground, while decomposition tends to obscure original differences in texture and composition. In all cases, however, the presence of woody muck or a small proportion of colloidal material gives weight or "body" to the soil which seems lacking in the pure fibrous material. Some of the best truck soils were formerly forested Peat land. In many other instances black, mucky material forms the subsurface, and has become mixed with the soil in cultivated fields.

The long, narrow area of Muck and Peat running through Scott and Jefferson Townships has been in cultivation more than 30 years. All of it will produce good crops of corn and clover. Much of this tract is used in the production of mint, onions, and potatoes. Hemp has been grown and produced very heavy yields, but its culture was abandoned for economic reasons. No crop troubles attributable to soil acidity or to "alkali" have been encountered in this area. In the main ditches the water (in 1920) stood at depths varying from 30 to 40 inches below the surface, and the flow is sluggish. The average level seems to be somewhat higher than it was a few years ago. This is doubtless a fortunate change, for if the average ground-water level were depressed to 6 or 8 feet the surface soil might become too dry for shallow-rooted plants. On the other hand, where the water stands within 15 or 20 inches of the surface it tends to keep the soil too wet. In some fields tile drains have been installed, but truck growers are of the opinion that they are not everywhere necessary.

The following cross section of a body of Muck and Peat was observed in the ditch, near the road in the NW. ¼ of the SW. ¼ of sec. 7, T. 34 N., R. 5 E.: From 0 to 18 inches in depth, forest peat with roots of trees in place, the material being granular with woody fragments; from 18 to 48 inches, a layer of fibrous, felty sedge peat (grass seeds and shells in the lower part), the material being oxidized to very dark brown; from 48 to 50 inches, greenish-gray, very fine sand and silt; from 50 to 63 inches, reddish-brown, loose, woody material, with small fragments from branches of trees, on sand and gravel. This seems fairly representative of a large proportion of the Muck and Peat in this county.

In the area west of the interurban railway between Leesburg and Milford, the Muck in places in the central part, is several feet deep. At one point where the subsoil is a woody peat, crystals of calcium sulphate are abundant in the interstices of the material. In this vicinity corn and some other crops sometimes fail to develop normally, but whether this is due to the presence of the calcium sulphate or to some other cause can not be stated. On the margin of this area excellent crops of corn and clover are usually harvested. Here, however, the Muck in most places is less than 20 or 30 inches deep and overlies calcareous gravel or gravelly clay. The drainage is generally good. At the time of the survey the water level in the ditches was 4 or 5 feet below the ground surface, which seems to be

1 or 2 feet higher than the average some years before. Good crops of corn, clover, and timothy are grown and there seems to be no reason why alsike clover or alfalfa should not do well.

The large area of Muck and Peat a few miles northwest of Atwood is variable with respect to character and depth of the surface materials and substrata. Much of the area near Hoffmans Lake is shallow and is underlain by marl. All of this area, which has good drainage, is well adapted to corn and truck crops. Some small patches west of the lake in section 36 are decidedly acid, and to this condition may be ascribed some crop difficulties experienced here and at a few other places in this locality. In the northeastern part of this large area depths of Peat ranging from 6 to 13 feet are reported.[3] On this deep Peat much of the natural vegetation remains, since the water table is high. Elsewhere blue grass has largely displaced the original vegetation and affords much pasturage.

In the northwest corner of section 19, 3 miles north of Atwood, a cross section of the Muck and Peat may be described as follows, beginning at the surface: From 0 to 4 inches, loose peaty sod with good blue grass and occasional bare patches heavily charged with bog-iron concretions; from 4 to 15 inches, a zone of blackish pulpy peat, consisting of an upper layer of weathered angular fragments and a lower layer of sticky material, fissured and having a somewhat rubbery consistence; from 15 to 25 inches, reddish-brown reed peat admixed with pulpy peat, and containing stems and root stalks which show some infiltration of iron; and from 25 to 40 inches, grayish or marly pulpy peat containing shells of various sizes and brownish roots scattered vertically. The deeper substrata appear to be alternate layers of blue clay and grayish, water-soaked sand. The water table occurs at a depth of 6 feet.

This cross section or profile, with respect to general character of the material, seems representative of much of this land. With similar drainage conditions such land affords good blue-grass pasturage and is adapted to corn and truck crops.

The smaller areas found throughout the county are more or less variable in the character of the material, but this is of less importance than the present drainage conditions. In some instances the ground-water level has been lowered too much. This is often indicated by crop conditions and by the cessation of summer growth of blue grass. Whenever the average water table drops below a depth of 30 or 40 inches, the surface layer, if not well shaded, is very apt to lose much of its moisture during dry, windy weather. This is particularly true of coarse fibrous peat, and to a less degree if it is "chaffy." Where much of the surface soil consists of woody muck or has a considerable admixture of colloidal material, it settles a little more firmly, and thus favors capillary rise of water. Shallow Muck, and that which contains a considerable proportion of sand and silt, resists dry weather, except where the water table has been greatly lowered.

The maintenance of the ground-water level at a depth of 30 or 40 inches seems to give satisfactory results on most cultivated areas.

[3] Peat Deposits of Northern Indiana; from thirty-first annual report of Department of Geological and Natural Resources of Indiana.

Truck growers state that tile drains are less efficient than open ditches in areas of deeper Muck.

Most of the Muck is either neutral or slightly alkaline. Crop troubles because of acidity seem rare, although they may occur on Muck which overlies sand or in a deep part where none of the water in the superficial layer has been in contact with the calcareous gravels and clays that so generally underlie all these organic soils. In many places comparatively shallow deposits rest directly upon marl, and in such instances it seems highly improbable that an acid condition can exist in the surface layer of well-drained ground. This also seems true of Muck over calcareous gravel or clay. Statements and field observations of others support this opinion.

Much of the corn, clover, and timothy of the county is produced on Muck and Peat areas. The yields are usually high, but the quality is inferior to that of similar crops grown on the Clyde and Maumee soils. For general farming Muck is not held in such high esteem by farmers as the mineral soils mentioned.

About 2,600 acres were devoted to mint in 1921 (county assessor's returns). In recent years the yields have ranged from 5 to 40 pounds of oil per acre, with an average of about 10 pounds. The price has been about $5 to $7 a pound. One successful grower reported a yield of 30 pounds per acre on 20 acres in 1920. About 800 pounds of potash per acre was used, and good tillage given. For mint, the ground is prepared in the fall, and cuttings are dropped into shallow furrows and lightly covered. If a good stand is obtained, the plants cover the ground in the spring and are ready for cutting about July 1. A second lighter cutting is often made in the fall. Mint hay, or the residue after the oil is extracted, has some value as cattle food.

In 1917 almost 2,000 acres of hemp were grown in the county, but hemp cutting has been almost abandoned for economic reasons. Vigorous plants still line the ditch banks and roadsides in many places.

Onions, celery, cabbage, and potatoes are very successfully grown with applications of potash fertilizers. On an efficiently drained field a mile west of Warsaw 800 bushels of onions per acre were produced in 1920, and Rural New Yorker potatoes yielded 150 bushels per acre, and are said to have been of excellent quality. Liberal applications of potash fertilizers were made on these crops.

The yields and quality of cabbage and celery in 1920 were excellent on local areas throughout the county. Tomatoes are less solid than similar varieties produced on mineral soils.

The present average value (1922) of Muck and Peat in condition for truck crops may be placed at about $100 an acre, but local values vary greatly, depending on location. For farm crops or for pasturage the value is lower.

Undrained areas remain in very much their original condition, with the natural vegetation unchanged. Where the latter consists chiefly of sedges and coarse grasses, the surface layer is usually a brown, coarse, fibrous material. These areas afford fairly good pasturage early in the season; and if the ground is firm enough for use of machinery, wild hay is harvested. Where tamaracks thrive there is a high water level, and more or less macerated peat underlies the woody surface layer. The area 3 miles southeast of Claypool is

mostly of this character, except the margins, which are partly in cultivation. There are a few small tamarack groves on the county boundary east of Barbee Lake. The areas marked with swamp symbols near the lakes are covered with rushes and cat-tails and the surface is permanently submerged. Their present value for recreational purposes and as refuges for many kinds of plants rarely found elsewhere in the county, seems to outweigh their value for agriculture.

Associated with Muck and Peat are deposits of marl, which are very numerous throughout the northern and central parts of the county. The marl beds form more or less of the bottoms of each of the larger lakes and they underlie many of the Muck and Peat beds. The marl varies in character from soft, whitish-gray, impure calcium carbonate to clayey or gravelly material containing comparatively little lime. Exposures along the shores of the lakes are very numerous, particularly in the northeastern part of the county. A large cement factory at Syracuse has used much marl from lakes Wawasee and Wabee. At the time of the survey 100 acres or more of undisturbed marl was exposed along the south side of Dewart Lake, with little or no overburden of Muck or Peat. On a few of the other lakes there are places where the marl may be loaded directly into a wagon; but usually dredging is necessary, or several feet of Muck must be stripped off, in order to obtain a quality of marl suitable for agricultural uses.

Many analyses of the better grades of marl show a carbonate content ranging from 70 to 90 per cent, expressed as calcium carbonate. The material has been used to a very slight extent as a soil amendment on fields close to the source of supply. Since upland soils are more or less acid, an increase in crop yields would doubtless follow the use of this marl for soil improvement. The economic value of such practice has not been worked out. Most of this marl is wet, adhesive material and involves a good deal of labor in handling. The recent development of mechanical devices for preparing marl for agricultural purposes has so reduced unit cost that large quantities of marl are now being used.[4]

SUMMARY

Kosciusko County is situated in the northern part of Indiana and has an area of 541 square miles. The greater part of the surface consists of undulating to rolling uplands. The largest areas of level land are in the northern part. There are about 40 lakes and innumerable beds of Muck. The original forest has largely disappeared, and the area is in an advanced stage of agricultural development.

Corn, oats, wheat, and clover are the chief crops. Tomatoes, onions, cabbage, mint, and sugar beets are extensively grown. Hogs and cattle are important sources of income on the great majority of farms.

The soils have been developed upon glacial deposits. Light-colored types prevail wherever the drainage has been good and the forest cover heavy. Dark-colored soils have developed mainly under conditions of poor drainage.

[4] The Value of Lime on Indiana Soils Bul. 213,, and Lime and Fertilizer Needs of Indiana Soils, Cir. 66, by Purdue Univ. Agr. Exp. Sta., Lafayette, Ind.

The Miami soils predominate on the uplands. They are grayish-brown soils overlying lighter-brown subsoils. They are better adapted to general farming than to special crops. The Crosby silt loam is related to the Miami silt loam, the former having developed, for the most part, under conditions of poorer drainage.

The Bellefontaine and Coloma soils are upland types which have developed from the more sandy and gravelly glacial deposits. They are not so well adapted to small grains as to fruits, vegetables, and truck crops.

The Fox soils are the dominant types on the sandy outwash plains near the lakes. The lighter types are fairly well adapted to small grains, grasses, and general crops, whereas the heavier types are excellent soils for general farming.

The Plainfield loamy sand has a nearly level topography, and is well suited for trucking.

The Warsaw soils, or the prairie types, are dark-brown soils well supplied with humus. They are held in high esteem for corn, small grains and clover.

The Maumee loam is a black soil with light-colored subsoil. It was formerly semimarshy but is now reclaimed. The light-colored phase is similar to the typical Maumee, except that the content of organic matter is less and the subsoil is somewhat better oxidized. Maumee loam has developed under poor drainage conditions. This soil is fertile and produces good crops of corn, clover, and other crops.

The Brookston and the Clyde soils are the dark-brown and the black types, respectively, found in the depressions in the uplands. They are well adapted to corn, clover and timothy.

The better-drained first bottoms are mapped as types of the Genesee series; the wet bottoms are called Swamp.

Accumulations of more or less decomposed organic matter, occupying naturally undrained or poorly drained depressions, are mapped as Muck and Peat.

PART II. THE MANAGEMENT OF KOSCIUSKO COUNTY SOILS

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INTRODUCTION

The farmer must know his soils and have a sound basis for every step in their management. Building up the productivity of a soil to a high level in a profitable way and then maintaining it is an achievement for which every farmer should strive. The business of farming should be conducted as intelligently and as carefully as any manufacturing business. Every process must be understood and regulated, from the raw material to the finished product, in order that it may be uniformly successful. The farmer's factory is his farm. Different soils present different problems. It is important, therefore, that soils be studied and understood in order that crops may be produced in the most satisfactory and profitable way.

It is the purpose of the following discussion to call attention to the deficiencies of the several soil types of Kosciusko County and to outline in a general way the treatments most needed and most likely to yield satisfactory results. No system of soil management can be satisfactory that does not, in the long run, produce profitable returns. Some soil treatments and methods of management may be profitable for a time, but ruinous in the end. One-sided or unbalanced soil treatments have been altogether too common in the history of farming in this country. A properly balanced system of treatment will make almost any soil profitably productive.

CHEMICAL COMPOSITION OF KOSCIUSKO COUNTY SOILS

The following table gives the results of chemical analyses of the soils of the different types in Kosciusko County, expressed in pounds of elements per acre, in 2,000,000 pounds of the surface of an acre, representing the plowed surface of the mineral soils, and a foot or more in the case of Muck:

Chemical composition of Kosciusko County soils

(Elements in pounds per acre, 2,000,000 pounds)

Element	No. 8, Miami sandy loam	No. 28, Miami loam	No. 12, Miami silt loam	No. 29, Miami loam, mottled-subsoil phase	No. 32S, Bellefontaine sandy loam	No. 39, Coloma loamy sand	No. 21, Brookston loam	No. 24, Brookston silt loam	No. 56, Clyde loam	No. 51, Clyde silty clay loam
Phosphorus [1]	1,400	960	700	1,050	790	960	1,220	1,400	1,570	2,270
Potassium [1]	2,350	2,350	4,540	2,520	1,180	840	4,710	2,350	3,870	2,690
Calcium [1]	3,290	2,580	2,140	4,570	1,740	2,570	13,000	19,420	20,200	55,570
Magnesium [1]	2,770	3,380	2,170	4,100	1,930	2,410	6,630	12,060	8,080	16,530
Manganese [1]	580	860	720	580	140	290	860	2,160	1,300	720
Iron [1]	14,540	17,670	28,360	22,370	20,520	14,680	17,390	43,610	18,240	15,110

[1] Soluble in strong hydrochloric acid (sp. gr. 1.115).

Chemical composition of Kosciusko County soils—Continued

Element	No. 8, Miami sandy loam	No. 28, Miami loam	No. 12, Miami silt loam	No. 29, Miami loam, mottled-subsoil phase	No. 32S, Bellefontaine sandy loam	No. 39, Coloma loamy sand	No. 21, Brookston loam	No. 24, Brookston silt loam	No. 56, Clyde loam	No. 51, Clyde silty clay loam
Aluminum [1]	30,440	18,240	31,500	28,420	13,580	14,420	46,580	55,260	62,470	67,980
Sulphur [1]	480	480	720	560	400	720	720	720	960	1,120
Phosphorus [2]	306	61	44	61	105	393	149	61	210	437
Potassium [2]	336	151	84	168	84	84	353	252	219	202
Nitrogen [3]	2,400	1,800	2,600	2,000	800	1,200	5,600	4,200	15,000	16,400
Potassium [3]	29,430	36,660	33,630	38,670	32,450	27,740	35,980	38,170	37,160	41,870

Element	No. 44, Plainfield loamy sand	No. 40, Fox sandy loam	No. 47, Fox loam	No. 43, Warsaw sandy loam	No. 42, Warsaw loam	No. 27, Maumee loam	Neutral Muck	Slightly acid Muck	Acid Muck
Phosphorus [1]	1,140	870	1,050	960	1,140	1,490	2,180	3,230	1,920
Potassium [1]	1,350	1,350	3,030	500	4,040	1,180	500	2,020	1,350
Calcium [1]	2,000	3,570	3,710	4,000	3,570	8,140	117,720	54,140	6,430
Magnesium [1]	2,410	1,220	2,050	2,770	2,170	2,170	5,590	2,890	2,650
Manganese [1]	140	860	1,010	860	1,150	720	1,150	2,590	1,440
Iron [1]	4,990	26,220	28,215	22,940	42,607	72,240	13,680	39,180	3,277
Aluminum [1]	26,410	25,980	32,980	16,550	36,590	36,300	18,350	27,890	9,760
Sulphur [1]	400	560	640	400	800	880	4,000	2,880	2,000
Phosphorus [2]	472	114	87	183	70	96	244	149	227
Potassium [2]	135	135	151	202	118	101	353	202	504
Nitrogen [3]	1,400	2,000	1,800	2,600	2,800	5,400	77,200	69,000	54,400
Potassium [3]	30,270	31,110	39,520	29,930	32,450	22,530	12,490	11,940	9,580

[1] Soluble in strong hydrochloric acid (sp. gr. 1.115).
[2] Soluble in weak nitric acid (fifth normal).
[3] Total elements.

Three groups of analyses are given: Elements soluble in strong (sp. gr. 1.115) hydrochloric acid, elements soluble in weak (fifth-normal) nitric acid, and total plant-food elements.

The total content of the elements is more valuable in indicating the origin of the soil than in determining the fertility. This is particularly true in the case of potassium. The quantity of total potassium in a soil is seldom an index of its need of potash. Some Indiana soils have over 30,000 pounds of total potassium per acre in the surface 6 inches, yet they fail to grow corn without potash fertilization, because so little of the potassium is available.

Total nitrogen is generally indicative of the needs for nitrogen, although some soils with low total nitrogen may have a supply of available nitrogen sufficient to grow a few large crops without the addition of nitrogen as fertilizer. Soils having a low total nitrogen content soon wear out, in so far as that element is concerned, unless the supply is replenished by legumes or the use of nitrogenous fertilizers.

The quantity of total phosphorus in ordinary soils is usually about the same as that shown by a determination made with strong acid. For this reason a separate determination of total phosphorus has been omitted. A low supply of total phosphorus usually indicates the need of a soil for phosphate fertilizers, although there are exceptions to this.

The quantity of phosphorus soluble in weak acid is considered by many authorities as a still better indication of the phosphate needs of a soil. The depth of a soil may modify its need of phosphates. Everything else being equal, the more phosphorus soluble in weak acid a soil contains, the less it is apt to need phosphate fertilizer. Whenever the phosphorus soluble in weak acid runs less than 100 pounds per acre, phosphates are usually needed.

The percentage of potassium soluble in strong or weak acid is to some extent significant. This determination, however, is not so reliable an indicator as the determination of phosphorus, particularly in case of soils of high lime content. Sandy soils and muck are more often in need of potash than clay and loam soils.

The use of strong or weak acid in the analysis of a soil has sometimes been criticized as having little or no value, yet analyses made with strong or weak acids more often can be correlated with crop production than can analyses made of the total elements of the soil. For this reason both strong and weak acid determinations have been employed in these analyses.

It must be admitted, however, that no one method of analysis can definitely indicate the deficiencies of a soil. For this reason these chemical data are not intended to be the sole guide in determining the soil needs. The depth of the soil, the physical character of the subsoil and surface soil, and the previous treatment and management of the soil are all factors of the greatest importance that should be taken into consideration.

In interpreting the soil map and the analyses, it should be borne in mind that a well-farmed and well-fertilized soil of a type which is naturally low in plant-food elements may produce larger crops than a poorly farmed soil of a type naturally rich in the nutrient elements. The better types of soils, including those showing large quantities of plant-food elements, will endure exhaustive cropping much longer than the less fertile types.

The nitrogen, phosphorus, and potassium contents of a soil are by no means the only chemical indications of high or low fertility. One of the most important factors in soil fertility is the degree of acidity. Soils which are very acid will not produce maximum yields even when there is no lack of nutrient elements. Nitrogen, phosphorus, and potassium can not act most effectively as fertilizing elements in soils deficient in lime.

The following table shows the percentage of volatile matter and acidity, expressed in pounds of lime carbonate required per acre, of the various soils found in the county. Samples were taken from the surface soil (0 to 6 inches), from the subsurface (6 to 18 inches), and from the subsoil (18 to 36 inches). It is important to know the reaction not only of the surface but of the lower layers of the soil.

Volatile matter and acidity of Kosciusko County soils

Sample number	Soil type	Depth	Volatile matter	Acidity [1] (pounds of lime carbonate required per acre)
		Inches	*Per cent*	
8	Miami sandy loam	0–6	3.95	20
		6–18	1.54	30
		18–36	1.92	30
2–S	Miami loam	0–6	3.35	215
		6–18	2.56	250
		18–36	2.76	1,450
12	Miami silt loam	0–6	4.77	100
		6–18	3.70	200
		18–36	4.91	110
29	Miami loam, mottled-subsoil phase	0–6	4.17	20
		6–18	2.48	675
		18–36	3.12	1,850
32–S	Bellefontaine sandy loam	0–6	1.79	100
		6–18	1.87	30
		18–36	2.87	80
39	Coloma loamy sand	0–6	1.95	50
		6–18	.96	50
		18–36	1.06	30
21	Brookston loam	0–6	8.47	25
		6–18	1.76	80
		18–36	1.79	80
24	Brookston silt loam	0–6	7.54	25
		6–18	3.10	20
		18–36	1.82	20
56	Clyde loam	0–6	20.70	75
		6–18	4.30	30
		18–36	3.18	12
51	Clyde silty clay loam	0–6	23.40	25
		6–18	3.10	50
		18–36	6.90	0
44	Plainfield loamy sand	0–6	3.05	115
		6–18	2.05	425
		18–36	1.10	515
40	Fox sandy loam	0–6	3.37	20
		6–18	2.44	40
		18–36	2.55	90
47	Fox loam	0–6	3.69	225
		6–18	3.40	110
		18–36	2.80	1,325
43	Warsaw sandy loam	0–6	3.88	100
		6–18	3.25	50
		18–36	1.65	30
42	Warsaw loam	0–6	5.41	244
		6–18	4.76	175
		18–36	3.84	1,030
27	Maumee loam	0–6	9.74	30
		6–18	5.77	20
		18–36	3.55	20
Neutral Muck	Neutral Muck	0–6	77.12	10
		6–18	42.72	150
		18–36	Marl.	0
Slightly acid Muck	Slightly acid Muck	0–6	79.16	320
		6–18	69.90	250
		18–36	67.96	200
Acid Muck	Very acid Muck	0–6	84.80	4,500
		6–18	14.10	12,000
		18–36	3.36	4,900

[1] Carbonate of lime required per acre determined by Hopkins' method.

As a general rule, a soil which is only slightly acid or neutral in reaction and in which the organic matter and nitrogen extend deeply into the subsurface, will be more fertile than a shallow acid soil. Given two soils of the same acidity in the surface soil, the soil with greater acidity in the subsurface needs lime much more than one in which the subsurface is less acid than the surface. Also, the more organic or volatile matter and nitrogen a soil contains and the deeper they extend into the subsoil, the less will be the need for lime, as compared with a soil of similar acidity and content of organic matter.

For convenience, the management of Kosciusko County soils will be discussed in relation to groups of soils having similar cropping characteristics or which require similar treatments for their improvement. Accordingly, the following groups of soils are considered: Light-colored upland silt loams; light-colored loams and sandy upland soils; dark-colored soils, other than Muck and Peat; and Muck and Peat soils.

LIGHT-COLORED UPLAND SILT LOAMS

Light-colored upland silt loams include the Miami and Crosby silt loams. There are only a few small areas of the Crosby silt loam. Both the Miami and Crosby soils are naturally deficient in phosphorus, nitrogen, and organic matter. They are also more or less in need of lime. In many cases potash is also needed. Practically all of this land should have tile drainage.

Drainage.—Most of this land has good surface drainage, but this is not sufficient for the best development of crops. The soil is fine in texture and the subsoil is so compact that surplus water does not readily drain away. Without underdrainage surface washing is more apt to occur. Rain water should be absorbed by the soil, and the surplus should pass away through underdrains. Underdrainage increases the capacity of the soil to absorb water, and it facilitates aeration, which is one of the things these soils need to make them more productive. Tile-drained land of this kind can be worked much more satisfactorily and can be cultivated several days sooner after a heavy rain than land not tiled. Tile drainage should therefore be included in the program for the improvement of these soils. The tile lines should be laid not more than 4 rods apart and not less than 30 inches or 3 feet deep. The tile lines should be carefully laid out with a surveyor's instrument and the grades properly established before digging the ditches, so as to make sure that all the water will flow to the outlet without interruption or slackening of the current. Checking of the current may cause the tile to fill with silt, and choke. It is an excellent plan, before filling the ditches, to cover the tile with a few inches of straw, or weeds or grass cut from the field. This will prevent silt from washing into the tile at the joints while the ground is settling, insuring perfect operation of the tile from the beginning.

Liming.—The need of lime should be determined by soil-acidity tests. If the farmer himself can not make the test, he can have it done by the county agricultural agent or by the agricultural experiment station at Lafayette. A strong indication of the need of liming will be found in the failure of clover to do well on the land. In many cases these soils will need some lime, and either ground limestone or marl should be used.

Organic matter and nitrogen.—Both the Miami and Crosby silt loams are low in organic matter and nitrogen. Constant cropping without adequate returns to the soil is constantly making matters worse. There is only one way of remedying this condition, and that is to plow under more organic matter than is removed from the soil by crops. Legumes should also be grown to supply needed nitrogen. To meet the nitrogen problem, the land must be put into condition to grow clover and other legumes. This means the ap-

plication of lime whenever the soil is acid, and also the application of soluble phosphates. After liming, at least 200 or 300 pounds per acre of acid phosphate should be applied. Wet lands must also be tile drained. Clover or other legumes should appear in the rotation every two or three years. As much manure as possible should be made from the produce fed on the farm, and all produce not fed, such as cornstalks, straw, and cover crops, should be returned to the land and plowed under. It must be remembered that legumes are the only crops that can add important quantities of nitrogen to the soil, and then only as green manure, when a crop is turned under, or as barnyard manure, produced by feeding clover. Whenever clover seed crops are harvested, the threshed haulm should be returned to the land and plowed under. Cover crops should be grown whenever possible to supply additional material for plowing under. Planting soy beans with the corn or seeding rye in the fall on corn land that is to be plowed the following spring are good practices to increase soil organic matter.

Crop rotation.—With tile drainage, liming, and proper fertilization, these soils will satisfactorily produce all the ordinary crops adapted to the county. On account of the organic matter and nitrogen shortage, however, every system of cropping should include clover or some other legume, to be returned to the land in one form or another. Corn, followed by wheat or oats, and then clover is the best short rotation, especially if the corn crop is removed so as to make possible the proper preparation of the land for wheat. In this position in the rotation, wheat needs an especially good fertilizer and the quantity applied should be sufficient to help the clover also. Corn, soy beans, wheat or oats, and clover is an excellent four-year rotation for these soils. If more corn is wanted, the rotation may be lengthened to five years by growing two crops in succession. This may be done satisfactorily by using a little more fertilizer.

Fertilization.—Both the Miami and Crosby soils are low in phosphorus and nitrogen. The total supply of potassium is large, but under the systems of cropping that have been followed, the soils in many fields are deficient in available supplies of this constituent. The problem of supplying nitrogen has been discussed in connection with provisions for supplying organic matter. Legumes and manure are the logical and only really practical means of supplying the bulk of the nitrogen needed and should be largely relied upon for this purpose. A livestock system of farming with plenty of legumes in the rotation is therefore best on these soils. This will largely take care of the nitrogen supplies for the grain crops. However, it will pay to have some nitrogen in the fertilizer for wheat, regardless of its place in the rotation. Even where wheat follows soy beans it should receive some fertilizer nitrogen because the nitrogen in the soy bean roots and stubble does not become available fast enough to be of much help to the wheat in the fall. These roots and stubble must first decay, and the decay does not take place to any considerable extent until the following spring.

Phosphorus is the mineral plant-food element most deficient in these soils. There is only one way to supply this, and that is by the application of phosphatic fertilizers. Since the natural supplies of phosphorus in these soils are low, provision should be made to supply

from outside sources all the phosphorus required by the crops grown. In rotations of ordinary crops producing reasonable yields, it may be counted that 20 pounds of "phosphoric acid" per acre per year is required. This can be supplied by applying an average of 125 pounds of 16 per cent acid phosphate, or its equivalent in some other soluble phosphate, per acre per year. This may be applied all at once or at various times during the rotation. Where manure is used, it may be counted that each ton supplies 5 pounds of "phosphoric acid," so that the quantity of phosphate to be purchased may be reduced accordingly.

The quantity of potash that should be supplied as fertilizer will depend upon the general condition of the soil and the quantity of manure used. In most cases the available potassium in the soil is so low as to seriously limit crop yields, and hence some potash fertilizer should be used until considerably more manure can be applied or until the general condition of the soil is materially improved. There is plenty of potassium in these soils if it could only be made available. Its availability may be materially increased by good farm practices, including proper tillage, tile drainage, the growing of legumes, and the plowing under of liberal quantities of organic matter. Not only manure but all unused crop residues should be plowed under, for the reason that these materials contain large quantities of available potassium. The better these practices are carried out, the less potash fertilizer will have to be purchased.

LIGHT-COLORED LOAMS AND SANDY UPLAND SOILS

In this group are included the Bellefontaine loam and sandy loam; Coloma loamy sand; Fox loam, sandy loam and gravelly sandy loam; Miami loam and sandy loam; Miami loam, mottled-subsoil phase; and Plainfield loamy sand. These soils are naturally deficient in phosphorus, nitrogen, and organic matter, and also available potassium. Most of them will be benefited by liming. In the light sandy soils, drainage is generally excessive, so that many areas suffer from drought, and need to have their water-holding power increased. This can be done by increasing the content of organic matter.

Liming.—Most of the light-colored loam and sandy soils of Kosciusko County will respond profitably to liming. In many cases liming is necessary before fertilizers can become fully effective. Thus liming may prove one of the best paying investments a farmer can make.

Soil acidity tests, which are easily made, determine definitely whether soils need lime. Clover failures and the abundant growth of sorrel on many fields may indicate the need of lime. Where a need for lime is indicated, from 1 to 3 tons of ground limestone to the acre, or its equivalent in marl, should be applied. Kosciusko County has many beds of marl within easy hauling distances of soils that need lime. Experiments have shown that marl is just as effective as ground limestone or any other form of lime for soil improvement. The marl of any particular deposit should be tested for its lime content in order to determine the rate at which it should be applied, since the marls of different deposits vary greatly in their lime content.

Organic matter and nitrogen.—All light-colored soils are deficient in organic matter. The light-colored sandy soils are particularly in need of this substance to increase their water-holding capacity and, in turn, to protect crops from droughts. All of these soils are also deficient in nitrogen. These two deficiencies go hand in hand, and both should receive the first attention of farmers located on these soils.

On the poorer soils of this group, the cheapest and most effective first aid, where little money is available, is to grow a crop of early maturing soy beans or cowpeas. In the long run, the soy bean is to be preferred either for feed or as a cash crop. Where grown for the first time, however, soy beans must be artificially inoculated with their special nitrogen-fixing bacteria. This can be done either with pure cultures or with soil taken from a place where inoculated soy beans have grown. Pure cultures, when purchased, are accompanied by instructions for their application. In the case of the soil method of inoculation, all that is necessary is to mix 3 or 4 quarts of the inoculated soil with each bushel of seed at planting time. In doing this, some farmers prefer first to slightly moisten the seed with a weak glue solution to make the soil stick to the seeds. The land should receive also an application of acid phosphate, or a mixture of phosphate and potash may be drilled with the seed. From 1½ to 2 bushels of seed per acre are the usual rates of planting. The crop should be cultivated with a harrow, weeder, or rotary hoe to break any crust that may form and to destroy weeds during the first few weeks after seeding. Immediately after harvesting the soy beans, the ground should be disked and seeded to rye or a mixture of rye and winter vetch fertilized with a high-grade, complete fertilizer, or at least, with a phosphate-and-potash mixture. If the soy-bean straw is not fed, it should be spread on the rye in the fall or winter. This cover crop should be plowed under late the following spring, and the land again seeded to soy beans. The second crop of soy beans is usually better than the first, partly because of the already improved condition of the soil but more largely because of better inoculation. If the land is very poor to begin with, it may be well to repeat the soy bean-and-rye treatment a third year before attempting to grow corn or other grain crops. This is the cheapest and quickest way to build up the fertility of these light sandy soils while at the same time to get a paying crop each year. The soy beans and rye will add the much needed nitrogen and organic matter and prepare the way for other profitable crop rotations.

The one thing to be remembered in the management of these sandy soils is that they use up organic matter very rapidly. The loose, open, excessively aerated condition favors rapid decomposition and oxidation, or the burning out of the soil organic matter. For this reason more than ordinary quantities of crop residue, manure, etc. must be constantly added. The land should never be left without something growing on it. Cover crops for plowing under should be inserted in the rotation wherever possible. More material must be plowed under than is removed from the soil.

Crop rotation.—As early as possible in this soil-improvement program, the land should be limed and put in condition to grow

clover. After that different rotations may be practiced on these soils. When the land is acid and lime is not used, a rotation of corn, rye, and soy beans may prove most practical. A cover crop of rye may be grown after the soy beans, for plowing under for the next crop of corn. On account of the droughty character of the sandy soils, and their lack of nitrogen, corn will not do well until after two or three years of the soy beans-and-rye treatment. After liming, clover may be introduced, as in a four-year rotation of corn, soy beans, rye, and clover. Rye or rye and vetch should be seeded in the corn in August to plow under for the soy beans. Where corn does fairly well, a five-year rotation of corn soy beans, corn, rye, and clover may be practical. In this rotation rye may be sown as a cover and green-manure crop after the first corn crop and after the soy beans. Alfalfa will do well on these soils after liming, and where this crop can be used a five-year rotation of corn, rye, and three years of alfalfa may be practiced. In some cases potatoes may be introduced into the rotation after clover and followed by rye and clover or several years of alfalfa. On the better soils wheat may be grown instead of rye. Grass crops are not adapted to these soils. Clover or alfalfa may be utilized for pasturage.

Fertilization.—The fact that these soils are deficient in nitrogen emphasizes the importance of growing legumes on them. Manure, of course, should also be utilized to the fullest possible extent. Fertilizer nitrogen can not be profitably purchased to any large extent. However, such crops as rye and potatoes should always receive some nitrogen in fertilizer form, even when they follow legumes.

Phosphates are needed in considerable quantities, because all of these soils are low in phosphorus. They are also low in available potassium, and require potash fertilizers, the more when little manure is used. Ordinarily, manure supplies from three to four times as much potassium as phosphorus.

The scheme of fertilization on these soils should be such as to supply all of the phosphorus required by the crops harvested. In addition to what is supplied in manure, the "phosphoric acid" to be added in fertilizer should be applied at the rate of from 15 to 20 pounds per acre per year. As a rule, most of the manure should be plowed under for corn, and most of the fertilizer should be applied when the small grains are sown. Where manure is scarce, 200 pounds of a 0–12–12 fertilizer should be broadcast for corn, and at planting time 100 pounds of a 2–12–6 mixture be applied in the drill row. The rye or wheat in the rotation should receive from 200 to 300 pounds of a 2–12–6 fertilizer per acre. For potatoes the same fertilizer may be used as for wheat, but at a considerably heavier rate. With these fertilizers and a constant and abundant supply of organic matter, including legumes, these soils can be made profitably productive.

DARK-COLORED SOILS, OTHER THAN MUCK AND PEAT

The dark-colored soils include Brookston loam and silt loam; Clyde loam and silty clay loam; Maumee loam; Maumee loam, light-colored phase; and Warsaw loam and sandy loam. With the exception of the Warsaw types, these soils are well supplied with organic matter and nitrogen, the Warsaw soils requiring careful

farming with respect to the maintenance of these constituents. By growing legumes in the rotations and utilizing crop residues and manure, the organic matter and nitrogen in these soils may be readily maintained.

Drainage.—The Maumee, Clyde, and Brookston soils are more or less in need of tile drainage. Considerable areas are already drained. The Warsaw soils are for the most part well drained, but in places the shallow depth to sands and gravels cause excessive drainage. The water-holding power of the soil on these leachy areas may be improved by increasing the content of organic matter.

Liming.—Considerable areas of the Maumee loam, light-colored phase, and some of the Warsaw areas are acid, and hence are in need of lime. Wherever there is doubt as to the need of lime, the soil should be tested for acidity. Here, as elsewhere, the failure of clover to do well after proper drainage may indicate a need of lime.

Crop rotation.—For the most part these soils will produce all the ordinary farm crops adapted to the region. The lower lying areas are not so good for winter small grains on account of the frequency of winterkilling. Furthermore, on some of these areas, where the straw grows rank, lodging of the grain reduces the yield and often smothers the clover seeding. Corn is well adapted to all of these soils and should be, generally, the principal crop. The low-lying areas are also good for meadows, timothy and alsike making a good mixture. On the Warsaw soils, a four-year rotation of corn, soy beans, wheat, oats or rye, and a three-year rotation of corn, small grain, and clover are good systems of cropping. The well-drained areas of Warsaw will produce excellent crops of alfalfa if properly supplied with lime and phosphate. As a temporary hay crop, Sudan grass may sometimes be used to advantage, and soy beans may be substituted as a legume hay crop whenever clover fails. Potatoes will also do well on most of this land, and much of it is well adapted to sugar beets.

Fertilization.—The Clyde, Maumee, and Brookston soils are naturally well supplied with nitrogen and, except for early truck crops, are not in need of nitrogenous fertilizers. On most of the Warsaw soils that have been cropped for a long time, some attention must be given to supplying nitrogen for the nonleguminous crops. This can and should be done by including legumes in the rotation and applying reasonable quantities of manure. Unused crop residues should be plowed under. Wheat should receive a good complete fertilizer.

Phosphatic fertilizers should be used in considerable quantities. The Warsaw soils and the light-colored phase of the Maumee loam are, as a rule, most in need of phosphate, to increase yields and to improve the quality of crops. Enough fertilizer should be used somewhere in each round of the rotation to supply an average of from 15 to 20 pounds of "phosphoric acid" per acre per year, depending upon the quantity of manure that is used. When no manure is used on corn, it will usually pay to broadcast 200 or 300 pounds of a 0–12–6 fertilizer while preparing the seed bed, and then apply 100 pounds in the drill row when the corn is planted. Wheat should receive 200 pounds of a 2–12–6 or a 2–12–4 fertilizer. For potatoes

300 or 400 pounds of a 2–12–6 mixture should be used. The use of these fertilizers will also take care of the potash needs, particularly if some manure is used.

MUCK AND PEAT SOILS

Muck and Peat soils include all of the highly organic soils of the county, containing from about 25 per cent to over 90 per cent of more or less decomposed organic matter mixed with sand and finer inorganic soil material. Probably 95 per cent of the Muck and Peat in Kosciusko County is of the nonacid type or what is known as "sweet muck," and only 5 per cent is of the acid or "sour muck" type. The latter is usually associated with the light-colored sandy soils of the Plainfield and Fox series, and is underlain with noncalcareous sands. The larger areas of nonacid or sweet mucks are associated with the soils of the Maumee, Clyde, and Warsaw series, and are underlain with calcareous or limy sands, gravels, clays, and marl deposits. Numerous smaller areas are found in depressions of the uplands in various parts of the county.

The profitable management of the Muck and Peat soils involves the following points: Proper drainage in all cases; the use of large quantities of potash, and usually some phosphate on the sweet Mucks; liming and the use of equal quantities of phosphate and potash on the acid Mucks; and a proper selection of crops to be grown. Many of the Muck and Peat areas have already been made highly productive, and most of them can be made equally productive by proper management.

Muck and Peat soils can not be permanently improved by burning, but instead they may be seriously injured. Burning adds nothing, but instead it destroys much valuable organic matter. The mineral plant-food elements concentrated in the ash remains are not to be considered as gain. These ash elements are soon used up and the land is left in a poorer condition than before, because of the destruction of organic matter and the consequent lowering of the land level to such an extent, in some cases, as to make drainage more difficult.

Drainage.—In improving Muck and Peat soils, the first requisite is proper drainage. Much of these soils in Kosciusko County has already been more or less drained by open ditches and some lines of tile. Some spots have been excessively drained by too deep ditches, with the result that crops suffer for want of moisture.

As a general rule, the water table in Muck and Peat soils should be lowered from 30 to 40 inches below the surface, but not lower than 4 feet. For meadows, 2 feet to the water table may be low enough for best results. Most of these lands will drain freely if the water has a chance to get away. Ditches and tile lines do not need to be so close together as in fine-textured soils. For ordinary conditions, the distance between tile lines or lateral ditches should be about 100 feet. Whether tile or open ditches should be used depends upon the local conditions. If the subsurface material is sufficiently firm to hold tile in place, tiling is to be preferred, since open ditches are always a nuisance. In extensive areas, large open outlet ditches may be necessary. These, however, should not be deeper than is neces-

sary to keep the water table at a proper level to meet the needs of crops.

Generally, areas of Muck and Peat receive considerable surface and seepage waters from the higher lands, and the plan of drainage must provide for the removal of these waters, as well as the excess water which falls upon the land itself. The first thing to be done is to cut a ditch or lay a line of tile along the edge of the marsh next to the higher land adjoining. This will catch the seepage from the higher land and make the drainage of the rest of the marsh area comparatively easy.

It has been stated that Muck and Peat soils should not be too deeply drained, for the reason that crops grown upon them are apt to suffer from a lack of water. However, tile lines must be placed deep enough so that the subsequent settling of the soil will not leave them too near the surface. After drainage Muck and Peat settle considerably within the first few years, and allowance for this should be made. The tile should be laid from 3½ to 4 feet below the surface, unless the Muck or Peat is already well settled from several years of drainage with open ditches. The aim should be, ultimately, to have the water table at a depth of about 3 feet below the surface. Great care should be excercised to establish an even grade for each line of tile, so that the flow of water will be uniform. Fine materials which get in at the tile joints settle easily and will soon clog the tile if the grade line is uneven. As a rule, nothing smaller than 5-inch tile should be used for Muck and Peat soils. It is a good plan to cover the tile with a few inches of hay or straw before filling the ditches. This will keep much fine material out of the tile while the ground is settling.

In some cases it may be necessary to raise the water table when the dry season of the year approaches, especially for shallow-rooted crops. This can be done by temporarily damming up the outlets of ditches or by blocking the tile outlets, thus holding back the water and raising the water table until sufficient rains come again.

Liming.—Only about 5 per cent of the Muck and Peat soils of Kosciusko County is acid enough to need lime. The few areas that do need lime need it so badly that this must be attended to before any other treatment can be effective. Some small areas are so very acid that it will hardly pay to lime them sufficiently for ordinary farm crops, unless accessible marl deposits can be found within easy hauling distance. In some cases from 15 to 20 loads of high-grade marl per acre, or the equivalent in ground limestone, will be required. On doubtful areas, careful acidity tests should be made to determine whether liming is really needed. Wherever blue grass thrives with proper fertilization, liming is not required.

Fertilization.—In the fertilization of the Muck and Peat soils of Kosciusko County, potash is of first importance, except on the very acid areas, where soluble phosphate is equally important. Nitrogen is present in great abundance in all Muck and Peat soils; hence the addition of nitrogen fertilizers is not required, except for early truck crops which need quickly available nitrogen. Especially is this true in late seasons when nitrification, the bacterial action which makes nitrogen available, does not begin early enough to supply these crops. For grains, legumes, and grasses the natural soil supplies of nitrogen become available fast enough to meet all needs.

Some of these lands when first brought under cultivation may produce a few good crops without the addition of potash; but the available potassium soon becomes exhausted and the only recourse is to supply this element from outside sources. In some cases, however, not even one good crop can be produced without the application of potash.

For the common field crops on these soils about 100 pounds of muriate of potash should be applied per acre per year, or 200 pounds every other year. Some of the "sweet" Muck and Peat soils need only potash; but in many cases, especially after some years of cropping, it will pay to add some soluble phosphate, or an 0–8–24 fertilizer, or a mixture of equal quantities of 16 per cent acid phosphate and 50 per cent muriate of potash should be applied at the rate of 200 pounds per acre per year. Higher-analysis phosphates, of course, may be used just as well by taking a smaller quantity to mix with the potash.

For truck crops the rate of application of fertilizers should be at least doubled. For celery sometimes as much as 2,000 pounds of fertilizer are used per acre. A 2–8–16 mixture is often used in large quantities for such crops as onions, lettuce, and cabbage. For some truck crops, especially potatoes, it may be advisable to use sulphate of potash instead of muriate in order to obtain better quality in the product. The sulphate usually produces a more mealy potato.

The acid Muck and Peat soils require fully as much soluble phosphate as potash, and hence, after proper liming, they should be fertilized with a 0–12–12 or 0–10–10 mixture, or their equivalents, as mixtures of equal parts of phosphate and potash materials.

Farm manure may be used to supply potassium and phosphorus to these soils. However, on farms having both organic and mineral soils the manure had better be applied to the mineral soils, because the organic soils do not need the nitrogen and organic matter supplied by the manure, whereas the mineral soils especially need these constituents. Sometimes the application of manure on raw Muck and Peat soils will be helpful in supplying beneficial bacteria which may be lacking, especially if the material is very raw or the land had always been very wet.

Crops for Muck and Peat soils.—The Muck and Peat soils of Kosciusko County, when properly drained and fertilized, may be satisfactorily used for all the field and garden crops adapted to the climatic conditions of the region, including many crops not adapted to the common upland soils. Most of the truck and small garden crops will do better on properly managed organic soils than on mineral soils. It may be said, therefore, that the farmer who has all Muck and Peat soil has a much greater range in the choice of crops that he may grow. The principal limiting factor is hand labor, the truck and garden crops requiring much hand work.

For the general farmer corn is the best crop for marsh areas. Muck soils can endure cropping with corn more than any other soils, except rich overflow bottoms. With plenty of potash and some phosphate, corn may be grown on Muck and Peat fields most of the time. It is necessary, however, to use much earlier varieties of corn in order to escape the early frosts. For a change in the

cropping system the following alternation of crops is suggested: First year, soy beans; second year, oats or rye, seeded with timothy and alsike clover; then a few years of meadow or pasture. The small grains are least adapted to Muck and Peat soils, because these crops are apt to produce a rank growth of weak straw which lodges badly. Liberal applications of potash will aid materially in producing stiffer straw.

Other crops adapted to Muck and Peat are mint, hemp, Sudan grass, sorgo, millet, buckwheat, sugar beets, turnips, mangels, and potatoes.

Of the truck crops, onions, cabbage, cauliflower, kale, rutabagas, celery, lettuce, parsnips, beets, and carrots do well on this kind of land.

Importance of compacting Muck and Peat soils.—One of the difficulties in managing Muck and Peat soils is that they are apt to be too loose on the surface. In preparing the seed bed, therefore, it is very important to pack the ground as much as possible by the use of a heavy roller, going over the field several times if necessary. Thorough compacting is not only better for crop growth, but it also aids materially in lessening the danger of early frosts.

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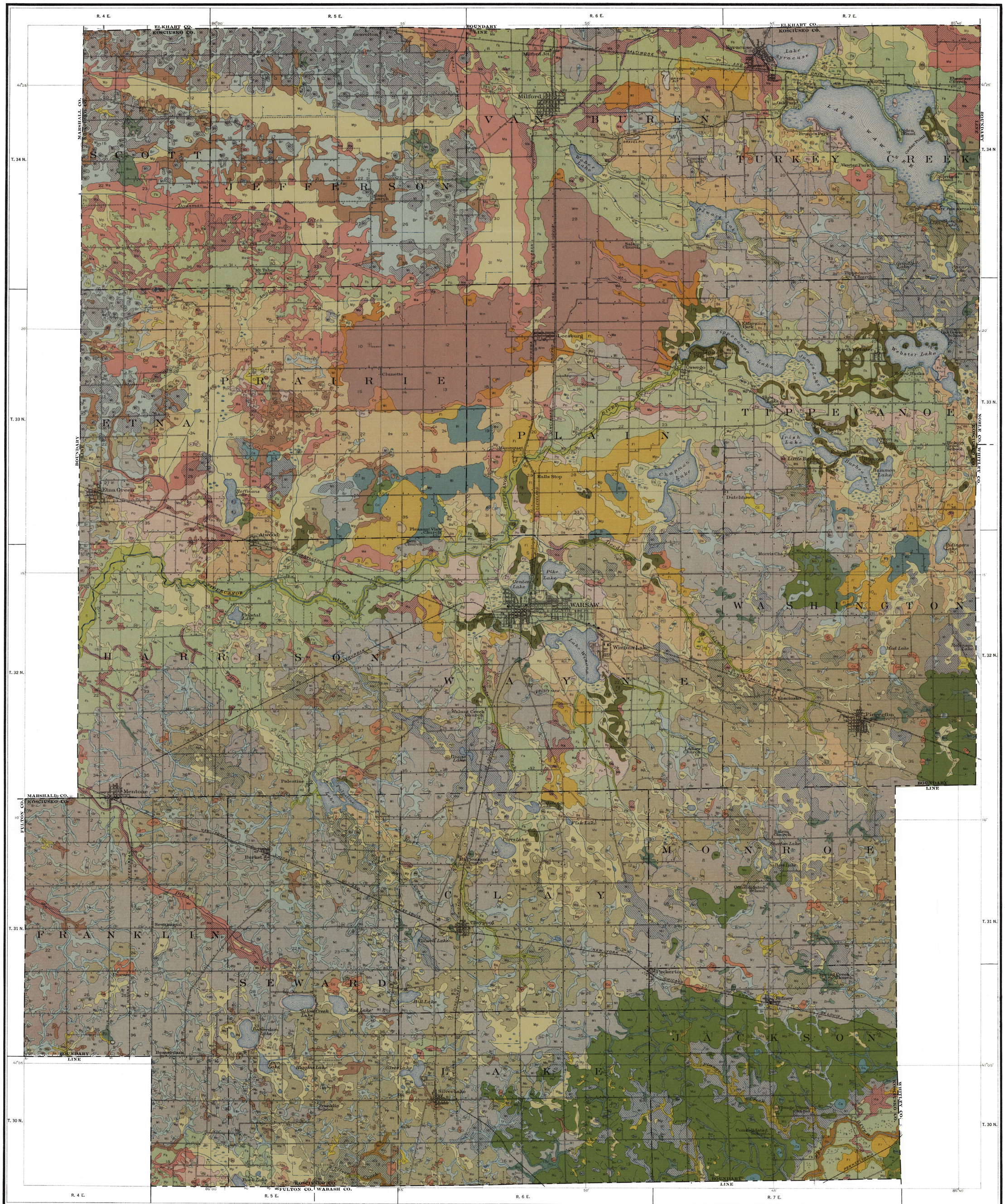
U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS
IN COOPERATION WITH THE
PURDUE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION

SOIL MAP

INDIANA
KOSCIUSKO COUNTY SHEET



LEGEND

- Bellefontaine sandy loam (Bs)
- Bellefontaine loam (Bl)
- Brookston loam (Br)
- Brookston silt loam (Bm)
- Clyde loam (Cl)
- Clyde silty clay loam (Cc)
- Coloma loamy sand (Co)
- Crosby silt loam (Cs)
- Fox gravelly sandy loam (Fg)
- Fox sandy loam (Fs)
- Fox loam (Fl)
- Genesee sandy loam (Gs)
- Genesee silt loam (Gl)
- Maumee loam (Ma)
- Maumee loam, Light colored phase (Ma)
- Miami sandy loam (Ms)
- Miami sandy loam, Rolling phase (Ms)
- Miami loam (Ml)
- Miami loam, Rolling phase (Ml)
- Miami loam, Mottled subsoil phase (Mo)
- Miami silt loam (Mo)
- Plainfield loamy sand (Po)
- Warsaw sandy loam (Wl)
- Warsaw loam (Wm)
- Muck and Peat (Mp)
- Swamp (S)

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort.

Secondary roads and Trails

Railroads, Steam and Electric

Bridges, Ferry

R.R. crossings, Tunnel

Ford, Dam

School or Church, Cemeteries

Mine or Quarry, Mine dumps, Made land

Bluff, Escarpment, Rock outcrop and Triangulation station

Stony and Gravelly areas

Soil boundaries

Boundary lines

Boundary lines

Boundary lines

U.S. township and section lines

RELIEF
(Printed in brown or black)

Contours, Depression contours

Prominent Hills, Mountain Peaks

Sand Wash and Sand dunes

Shore and Low-water line, Sandbar

DRAINAGE
(Printed in blue)

Streams

Lakes, Ponds, Intermittent lakes

Intermittent streams

Springs, Canals and Ditches, Flumes

Swamp, Salt marshes

Submerged marsh, Tidal flats

The above signs are in current use on the soil maps. Variations from this usage appear in some maps of earlier dates

Soils surveyed by W. E. Tharp, in charge, and Earl D. Fowler of the U. S. Department of Agriculture and L. S. Troth and H. R. Beyer of the Purdue University Agricultural Experiment Station.

1 ½ 0 1 2 3 4 Miles

Scale 1 inch = 1 mile

A. Hoen & Co. Lith. Baltimore, Md.

Field Operations
Bureau of Soils
1922